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EDITORIAL

Welcome to reading the 2012 edition of the annual publication *Acta Kinesiologiae Universitatis Tartuensis* that has undergone a number of changes in comparison with the previous issues.

Beginning with this issue, a new editor has been appointed by the Faculty of Exercise and Sport Sciences of the University of Tartu – the former editor, Professor Toivo Jürimäe has retired and from this academic year bears the title *professor emeritus*. The format of our journal has been changed, and we believe it has become more reader-friendly. Several new researchers have been invited to join the Editorial Board – specifically, a new local group joined the international editorial team to help further improve the content of our journal. From this issue, Tartu University Press sees *Acta Kinesiologiae Universitatis Tartuensis* as one of the leading journals published by them, and so they will render additional help in its producing process. Most important of all, our journal has now become an Open Access publication, this means free access to all articles in this year's edition and in previous issues. *Acta Kinesiologiae Universitatis Tartuensis* can be read from the following link: http://ojs.utlib.ee/index.php/AKUT/. As before, our peer-reviewed journal is indexed in Sport Discus Database, and we are working towards the goal of getting indexed in other major international databases.

To become an even more important journal in the area of sport sciences, we wish to print a wide spectrum of the newest findings by scientists all over the world. The journal continues to publish research articles in several areas – exercise physiology, sports psychology, sports pedagogy, physiotherapy, anthropometry, coaching science – and the list goes on since there are overlapping regions related to sport sciences and physical education. Review articles, original scientific papers, case studies and short communications are all welcome. We would like to publish in every issue at least one review article in an important area of sport sciences. In this issue, one review paper brings together insights from research on teacher behaviour related with students' motivation and learning in physical education, while another review article deals with the clinical management of immunosuppression in athletes. You will also find original articles on physiotherapy, coaching sciences, exercise physiology, ergonomics, health sciences, pediatric exercise sciences and body composition in this issue.

To help authors – previous contributors and newcomers – to submit their articles to this journal, we have shortened the reviewing process to 4–6 weeks and provide quick feedback. This pre-publication process will retain and enhance the international standard of the published material. We are grateful to the national and international reviewers for their input to improve our articles and count on their contribution in the future issues. There can be no research journal without enthusiastic scientists wishing to fill it with appropriate content – so the gratitude is definitely extended to all current and future authors. Together we can and shall improve *Acta Kinesiologiae Universitatis Tartuensis,* making it more visible for the international scientific community. We expect to receive new articles for the next issue of our journal and hope that you consider it as a good place to publish your research results in sport sciences.

Jaak Jürimäe, PhD
Editor-in-Chief

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THE EFFECT OF TEACHER BEHAVIOUR ON STUDENTS MOTIVATION AND LEARNING OUTCOMES: A REVIEW

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ABSTRACT

The aim of the current paper is to bring together insights from research on teacher behaviour related with student's motivation and learning in physical education. Teacher behaviour is analysed in terms of two independent behaviour dimensions called teacher interpersonal behaviour and teaching styles (methods). The analysis is based on self-determination theory. More specifically, the effect of the autonomy supportive and controlling teacher on student's motivation and learning outcome in physical education context are discussed. Also, a brief review of the instruments to measure controlling and autonomy supportive teacher's behaviour is presented.

Keywords: *autonomy supportive and controlling teacher behaviour, teaching styles, self-determined behaviour*

INTRODUCTION

Teacher behaviour is one of the key determinants in forming the student's motivation and learning. Self-determination Theory (SDT) [12, 13, 14] is one of the most widely used theoretical frameworks to study motivation. Central to SDT is the distinction between autonomous and controlling forms of motivation. SDT focuses on the extent to which different types of motivation (intrinsic, identified, interjected, extrinsic and amotivated) are autonomous or self-determined and explains how social factors like behaviour of significant others and social environment impact on motivation through the satisfaction of psychological need for autonomy, competence and relatedness. To be self-determined means to act with a sense of volition and choice [35]. To be controlled means to act with feeling of pressure [14]. SDT states that the context in which the activity is presented can make a difference to a person's level of motivation. If the activity is presented in such a way to encourage a sense of choice, highlight the important reasons for doing so, it is more likely to be intrinsically motivating and people are more likely to persist in doing the activities. Such an environment can be engendered by significant others like teachers and is known as autonomy supportive. An autonomy-supportive environment can be promoted through the adoption of specific behaviours by teachers that enhance intrinsic motivation in students. In contrast, the environment is said to be controlling when teachers do not provide meaningful rationale, use pressuring language, and pressure individuals accept their points of view [16].

Teacher behaviour in respect of interpersonal communication may be viewed as student's autonomy supportive or controlling. Several researchers [31, 33, 39] using the SDT, have examined the behaviours of autonomy-supportive and controlling teachers for the purpose of distinguishing more clearly what is meant by these two types of behaviours. Reeve and Jang [33] have characterized an autonomy-supportive teacher as responsive (e.g. spend time listening, acknowledge the student's feelings and perspective), supportive (e.g. praise the quality of performance), explicative (e.g. provide a rationale for tasks and limits); and who provides choice and opportunities for initiative taking and independent work, and offers student discussion time. In contrast, Assor et al. [1] have noted that controlling teacher in essence takes charge (e.g. hold the instructional materials, use directives/commands), shapes students toward a right answer (e.g. give solutions), motivates through pressure (e.g. threats, criticisms and deadlines), and doesn't allow students to work at their own pace.

Recently, Sierens with his colleagues [49] investigating the antecedents of teaching styles has distinguished three sources: pressure from above, from within, and from below. Pressure from above refers to pressure from principals, parents and colleagues, whereas pressure from within and pressure from below refer to stressful conditions in the functioning of teachers themselves and of their students, respectively. One important feature of pressure from within is teachers' own motivational orientation. According to SDT [36], self-determined motivation (i.e., intrinsic motivation) stems from the perceived fulfilment of three psychological needs: autonomy, competence, and relatedness. The results presented by Carson and Chase [5] showed that PE teachers' self-determined motivation related positively and strongly with the perceived fulfilment of autonomy, competence, and relatedness. That's mean that when psychological need for autonomy, competence and relatedness are satisfied, the teacher will be more motivated to teach. More specifically, perceptions of autonomy, competences, and relatedness were most closely aligned with intrinsic motivations to know, to accomplish, and experience stimulation. Also teachers may perceive their students as high or low on quality of motivation, and a perception of low-quality motivation in students may represent another source of pressure for teachers. Regarding this statement, previous research using SDT theory have shown that when teachers believed that students were autonomously motivated they were more autonomy supportive and less controlling [28, 42] and that the impact of students' motivation on teachers' interpersonal behaviours was actually mediated by teachers' motivation [29, 51, 52]. Taken together, these results support an assumption that, when teachers interact with students, they often rely on their perceptions on the students' motivation as guides to their interpersonal behaviours.

TEACHER INTERPERSONAL STYLE: AUTONOMY SUPPORTIVE BEHAVIOUR

Research has shown that the level of perceived autonomy support given by significant others is associated with autonomous forms of motivation and behavioural persistence [8, 54]. Considerable research has shown the motivational implications of perceived autonomy support in physical education settings [19, 20, 22, 30, 43, 44, 45, 46]. For example, using structural equation modelling, Standage and colleagues [46] tested the relationships among perceived autonomy support from teachers, students' need satisfaction and motivational orientation, and the teachers' ratings of the students' motivated behaviour. Results of this study with the sample of 11–14 year old students provided strong support for the pattern of relationships predicted by SDT. Specifically, results showed that students' perceptions of autonomy support demonstrated by their teachers positively predicted the students' perceived competence, autonomy, and relatedness, which in turn, each positively related to the students' motivational orientation for physical education. Further, the degree to which the students reported more self-determined motivation positively related to the amount of effort and persistence they demonstrated as indicated by their physical education teacher.

The trans-contextual model of motivation proposed by Hagger et al. [19] showed that perceived autonomy support in PE context influenced not only autonomous forms of motivation (intrinsic motivation and identified regulation) in PE but also predicted autonomous forms of motivation on physical activity in leisure-time context. Cross-cultural studies using the trans-contextual model of motivation among Britain, Greece, Poland, and Singapore students [20] and among Britain, Estonia, Finland, and Hungary [21] confirmed the effect of perceived autonomy support from PE teachers on students' motivation in PE and in leisure time contexts. These models demonstrated clearly that the influence of perceived autonomy support from PE teachers on autonomous motivation in a leisure-time context and leisure time physical activity, which is one of the main objectives of PE, will be mediated by autonomous motivation in PE.

Instrument to measure autonomy supportive behaviour

One of the widely used instrument to measure the autonomy supportive behaviour from significant others is Learning Climate Questionnaire (LCQ). This questionnaire was adapted by Williams and Deci [55] from the Health-Care Climate Questionnaire [56]. Several authors [19, 38] have used this scale in physical education and sport contexts to measure perception of the autonomy supportive behaviour from teachers and coaches. The LCQ has a single underlying factor with high internal consistency. The internal reliability (Cronbach's alpha) for this scale was satisfactory across samples (0.91; 0.82; 0.91; 0.95; 0.91; 0.92; and 0.91 for British, Greek, Polish, Singaporean, Estonian, Hungarian, and Finnish sample, respectively) [20, 21, 22]. Several authors [34, 47] measured also perceived autonomy support using a short (6 items) version of the original 15 items Health Care Climate Questionnaire [56.]

However, in sport context, an instrument to measure two forms of perceived autonomy support from coaches' (Autonomy-Supportive Coaching Questionnaire, ASCQ) was developed [9]. The presented forms were: interest in athletes' input (five items) and praise for autonomous behaviour (four items).

Stefanou with colleagues [48] proposed that autonomy support can be manifested in the three distinct ways: organizational autonomy support (e.g., allowing students to choose group members, choose evaluation procedure, to participate in creating and implementing rules), procedural autonomy support (e.g., offering students to choose materials to use in class, choose the way competence will be demonstrated, discuss their wants), and cognitive autonomy support (e.g., offering opportunities for students to evaluate work from a self-referent standard).

Recently, an instrument to measure four dimension of English language teachers' autonomy support in Malaysia was developed [53]. This instrument involves the following dimensions: being responsible, being friendly, showing respect and encourage confidence.

TEACHER INTERPERSONAL STYLE: CONTROLLING BEHAVIOUR

Early studies [15, 17] have shown that students in classrooms with controlling teachers displayed more extrinsic motivation, and lower perceived competence and self-esteem, than did students with autonomy supportive teachers. A considerable body of research has shown that controlling environment contribute to low achievement, anxiety, preference for easy work and dependence on others to evaluate their work [e.g., 4]. Teachers in a position of authority can exhibit a controlling interpersonal style. In this case they can behave in a coercive, pressuring, and authoritarian way in order to impose a specific way of thinking and behaving upon their students. The external pressures applied by the teacher are perceived by the students to be the origin of their behaviour and the resultant loss of control undermines the students' psychological needs and sense of self-determination [12]. In other words, controlling teaching behaviours induce a change in the students' perceived locus of causality from internal to external [36]. The study among Estonian students [23] confirmed this statement showing a negative direct effect of perceived autocratic leadership behaviour on student's motivation and positive from teaching and instruction.

Instrument to measure controlling behaviour

In the educational context the teacher's controlling behaviour is usually measured by one-dimensional scale [1, 32, 50] with selected and adopted items from different scales [2, 40].

Recently, the instrument to measure multidimensionality of the perception of the coaches' perceived controlling behaviour has been proposed [3]. This instrument of Controlling Coach Behaviors Scale (CCBS) comprises 4 factors: controlling use of rewards, conditional regard, intimidation, and excessive personal control. An initial version of the instrument contained also the judging and devaluing subscale with four items reflecting the behaviours coaches may engage in that actively undermine athletes' feelings of self-worth. However, this scale was removed from the questionnaire due to high interfactor correlations.

All four remained subscales (factors) consisted of three items. Factor 1, *Controlling Use of Rewards,* consisted of the items that reflected coaches' use of extrinsic rewards and praise to induce athlete engagement or persistence in certain behaviours (e.g., "The only reason my coach rewards/praises me is to make me train harder"), Factor 2, the use of *Conditional Regard*, consisted of the items that reflected cases in which coaches withhold attention and support from athletes who do not display desired attributes and behaviours (e.g., "My coach is less friendly with me if I don't make the effort to see things his/her way"). Factor 3, *Intimidation,* consisted of the items that reflected the strategies coaches may use to intimidate their athletes into emitting requested behaviours (e.g., "My coach uses the threat of punishment to keep me in line during training"). Factor 4, *Excessive Personal Control,* consisted also of three items that reflected coaches' over-intrusive behaviours (e.g., "My coach tries to interfere in aspects of my life outside of my sport").

Up to date different dimensions of the teachers' controlling behaviour perceived by students are not established and their role on learning outcomes remains unclear.

Therefore, there is a need for a multidimensional instrument to measure the teacher controlling behaviour by tapping the extent to which students perceive their teacher to engage in a variety of controlling behaviours during teacher-students interactions. It will be assumed that multidimensional instrument will allow discovering the darker side of teaching learning process.

TEACHING STYLES

Mosston's Spectrum of teaching styles [26, 27] established a framework of possible options in the relationship between teacher and learner and was based on the central importance of decision-making. The Spectrum [11, 27] consists of ten teaching styles based on the degree to which the teacher or the student assumes responsibility for what occurs in a lesson. This describes a continuum, where at one side is the direct, teacher-led approach (reproductive style) and at the other lies a much more open-ended and student-centered style (productive style) where the teacher acts only as facilitator. Some similarities can be drawn between two types of teacher's interpersonal behaviour and the Mosston's teaching styles. Student-centered teaching styles may be considered as autonomy-supportive behaviour and teacher-centered teaching styles as controlling behaviour.

A few interventions studies have been shown that the use of reproductive teaching styles resulted in forming more performance- and less mastery focused motivational climate [25, 37]. Morgan et al. [25] found that the use of pupil-centered reciprocal and guided discovery styles resulted in more mastery and less performance focused teaching behaviours than the traditional command or practice styles. Recently, Sicilia-Camacho and Brown [41] described the revised concept of the Spectrum of teaching styles, in which the conceptual basis of Spectrum has moved away from setting one teaching style against another, or from a versus to a non-versus style. In brief, there is no single excellent or superior teaching style or teaching-learning approach [27]. All teaching styles, when used appropriately, contribute to human development in different ways. Consequently, the use and significance of each individual style will be determined by the teaching objectives or by desired learning outcomes. Number of studies have dealt with the effects of different teaching styles on widely recognized objectives of PE like motor skill acquisition, affective state, cognition and social skills [see for reviews 6, 7]. Chatoupis [6] highlighted the need to investigate the outcomes and contributions of different teaching styles, for a particular period of time, to teach content rather than to compare one style against another. According to the same author, in a typical school lesson most teachers use several teaching styles to achieve different objectives.

The differences and frequencies in use of teaching styles among teachers from different countries were also investigated [10, 18, 24]. For instance, the study [10] in which cross-cultural differences in the use of the different teaching styles in seven countries (Korea, Australia, France, England, Portugal, Canada and U.S.) were observed, the differences ranging from minor to substantial across those countries were found. All countries were significantly different in the use of the command style. Korean teachers differed in all styles from the other six countries. The teachers from England, Australia, and Canada reported the more frequent use of productive styles than Korean and Portuguese teachers. However, command and practice styles were the most preferred reproductive styles, whereas guided discovery, convergent discovery and divergent production styles were the most employed productive teaching styles. Similar results in respect of the use of reproductive styles were found in the study among Spanish, Estonian, Lithuanian, Latvian and Hungarian teachers [18]. No differences were found in the use for guided discovery and divergent styles. The results of this study also indicated to the existence of a strong correlation between productive styles and intrinsic motivation and between reproductive teaching styles with more external types of motivation.

CONCLUSION

Considerable research has shown that students' perceptions of autonomy supportive behaviour from teachers were positively related to the self-determined motivation whereas the perception of controlling undermined it. According to a new conception of the Spectrum of teaching styles the use of each style depends of the teaching objectives in PE, which also undoubtedly include motivating students to be physically active even after their school graduation. Therefore, it allows also the consideration that the use of productive styles seems to be more important than reproductive styles which are more appropriate for motor skill acquisition. However, only acquiring some motor skills enable to be physically active.

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CLINICAL MANAGEMENT OF IMMUNO-SUPPRESSION IN SPORTSMEN-WOMEN: RECOMMENDATIONS FOR SPORTS MEDICINE PHYSICIANS AND PHYSIOTHERAPISTS

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ABSTRACT

In sportsmen and sportswomen the Overtraining Syndrome (OTS) can be a physically debilitating *medical* condition that results in these men and women being totally compromised in their capacity to perform and compete athletically. Many physiological systems are affected by the process of overtraining and the OTS; but one system in particular, the immune, is highly susceptible to degradation resulting in a reduction in overall health and performance. The aim of this paper is twofold; 1) to review the evidence-based proactive steps and actions to greatly reduce the risk of development of an infection or a compromised immune system in sportsmen; and 2) to recommend the course of action for clinicians when they are dealing with an sportsmen and women displaying overt signs of an infection and, or inflammation. Based upon the evidence reviewed-presented herewithin, it can be concluded that it is essential for clinicians to take practical preventative and management steps – actions with sportsmen-women involved in intensive exercise training in order to help preserve a healthy and robust immune system.

Keywords: *overtraining, immune, cytokines, sports, stress, hormones, sports performance*

INTRODUCTION

The focus of an exercise training program in sportsmen and sportswomen is to improve their physical performance capacity in select sporting events. In attempting to enhance physical performance and cause positive physiological adaptations, competitive sportsmen and sportswomen (i.e. athletes) must perform a remarkable amount of exercise on a systematic basis. If the exercise training regimen stresses are excessive (involving working at too great an intensity, and/or containing too great a volume of work), or an athlete has too many additional life stresses (e.g. emotional worry, financial concerns) during training, it is possible for physiological mal-adaptations to occur. Such physiological mal-adaptations can lead to physical performance declines. In the field of exercise physiology this process of applying excessive training stress is referred to as overreaching-overtraining [3, 8, 9]. If overreaching-overtraining is persistently applied to an athlete, then there is the potential for the medical condition called the Overtraining Syndrome to develop in the individual [6, 12, 18].

The Overtraining Syndrome (OTS) is a physically *debilitating medical* condition that results in an athlete being totally compromised in their capacity to perform and compete in sporting events. Table 1 presents some of the most common signs and symptoms associated with overtraining and the development of the OTS. The information in Table 1 indicates that a multitude of physiological systems can be affected by the OTS. Recent research evidence points to one system in particular being profoundly affected by overtraining; that system is the immune system. Findings point to a compromise of the immune system when exercise training becomes excessive, and as well documented a compromised immunological function can impact greatly on many aspects of an athlete's health. To this end, the intent of this paper is to provide recommended steps for sports medicine clinicians toward management and care to prevent and, or treat some of the health consequences of overreaching-overtraining and OTS as related to the immune system established by using current evidence-based research findings.

Background – immunosuppression

The actions of the immune system can be divided into what are referred to as the *Innate* and *Adaptive* immune responses. The innate responses are the first line of immunological defense and are viewed as indiscriminately attacking pathogens, while the adaptive responses (which typically follow those of the innate) tend to target specific pathogens and have an antigen-specific memory of such pathogens [23]. Figure 1 gives a schematic overview of the general aspects of these components to the immune system. Both the innate and adaptive immune responses are associated with the production of cytokines (see references 1 and 23 for an overview of cytokine type and function). There are a multitude of cytokines that can be produced, and they are typically classified as either pro-inflammatory or anti-inflammatory in function; although, some cytokines have both pro- and anti-inflammatory actions [23]. Research by Smith indicates intensive exercise training resulting in skeletal muscle tissue trauma [23]. This tissue trauma from exercise (if excessive) results in the production of an abundance of pro-inflammatory cytokines, which then leads to the development of a sickness response or a chronic fatigue-like behavior in an athlete [19, 20, 21]. The key pro-inflammatory cytokines most associated with this trauma events are; interleukin-1 beta (IL-1β), interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α) [1]. Research by several investigators has produced findings that substantiate the role of pro-inflammatory cytokines, especially IL-6, as being key physiological mediator and modulator for development of many of the symptoms associated with OTS (see Table 1) [20, 21].

Research evidence points to the production of pro-inflammatory cytokines facilitating the up-regulation of humoral immunity and the suppression of the cell-mediated immunity components of the adaptive immune responses [1, 23]. Because of its immune system role, development of cell-mediated immunosuppression increases the risk of illness or illness-like symptoms such as upper respiratory symptoms (URS) and infections (URI). The development of such an illness or illness-like symptoms can be further associated with compromises in physical performance capacity in athletes – that is, they find exercise training or competition difficult or impossible under such conditions [5, 16, 25].

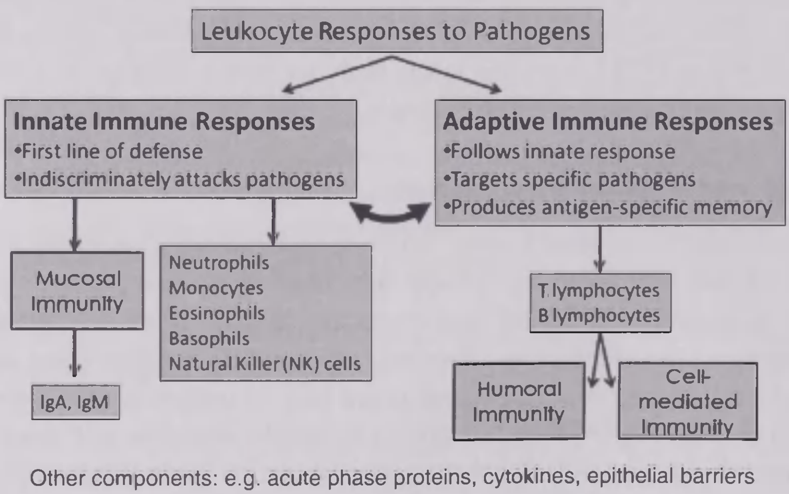

Figure 1. Schematic overview of the basic components of the immune system. IgA=Immunoglobulin A; IgM=immunoglobulin M)

Table 1. Some of the major signs and symptoms of overtraining and the Overtraining Syndrome

Physiological Function:
Decreased competitive performance
Decreased muscular strength
Increased muscular soreness
Chronic fatigue
Reduced tolerance to training overload
Sleep-wake cycle abnormalities
Gastrointestinal disturbances
Reduced testosterone levels
Reduced thyroid hormone levels
Elevated cortisol levels
Elevated creatine kinase
Altered lactate responses to exercise
Reduced sexual drive and libido
Altered heart rate responses to exercise
Suppressed immunological function
Psychological Function:
Increased feelings of depression
Lethargy and apathy
Emotional abnormalities
Loss of appetite
Lack of competitive drive
Restlessness
Difficulty in concentrating

Note: See reference 15 for details

These phenomena of cell-mediated immunosuppression and increased URS-URI risk are in-line with what are referred to as the "Open Window" and "J-Curve Response" concepts which are related to exercise training and illness developmental state as proposed by several eminent health researchers [13, 16, 26]. The open window concept entails that after an intensive exercise session there is a period of time (typically 3–72 hours) in which there is an increased susceptibility to illnesses, such as URI. If there is insufficient daily rest then there can be a cumulative effect of consecutive days of intensive training (i.e. the "window" staying open for a longer period of time). This notion of a period of increased susceptibility to illness following exercise has been linked to the occurrence of natural killer (NK) cell inhibition (part of the innate immune responses [immune-suppression]) that can happen after an exercise session brought on by the increased levels of cortisol, catecholamines, pro-inflammatory cytokines, and increased prostaglandins (from monocytes) in response to the exercise session [1, 7, 11, 17, 26]. The NK cell suppression in turn seems to assist in the aspects of the greater adaptive immune responses and the up-regulation of humoral immunity and down-regulation of cell-mediated immunity [1, 19, 23]. Interestingly, NK cell suppression is especially associated with and found following prolonged-duration endurance (aerobic) forms of exercise activities (e.g. marathon training) which have some of the highest incidences of OTS development [18, 21, 24]. In a similar fashion, the J-curve response concept states that the risk of URI development initially goes down as a sedentary individual gets involved with light to moderate exercise training for health and fitness, but the prevalence substantially increases as the individual advances their training to higher levels of volume and/or intensity such as occurs in individuals wanting to compete in sporting activities; Figures 2 and 3 display diagrammatic depictions of these concepts.

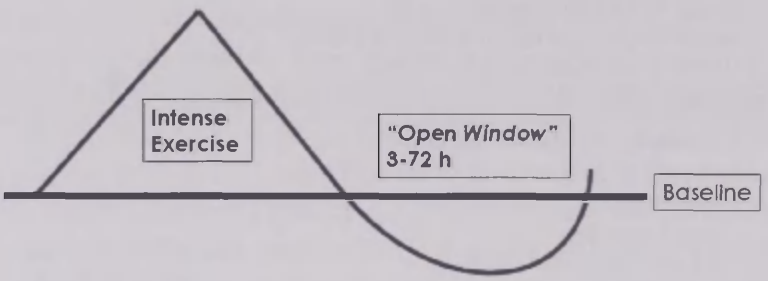

Figure 2. Open Window theoretical concept associated with immune responses to acute exercise. h=hours

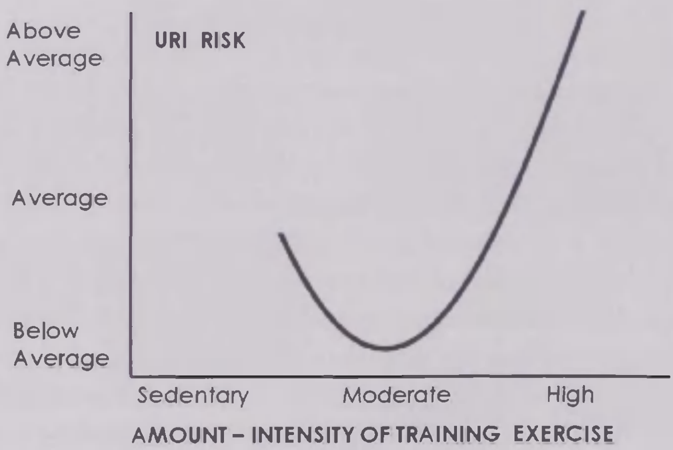

Figure 3. J-Curve response concept associated with the immune responses to exercise training. URI=upper respiratory infections

Practical aspects of dealing with immunosuppression

As noted above, the evidence supports that development of exercise training induced immunosuppression is associated with compromised physical performance [25, 26]. Nevertheless, development of an infection of any type, for any reason, in an athlete can lead to an inability to exercise train or compete at an optimal level [16, 25] Therefore, it is important for sports medicine clinicians to take and recognize preventative – treatment steps and actions to allow for maintenance of appropriate immune function and health in sportsmen-women [14].

Prevention

As with nearly all medical and health conditions, prevention is far superior to treatment in providing for a more successful overall maintenance of the athlete's training regimen and physical performance capacity. Research findings support that there are several proactive steps and actions that sportsmen and sports medicine clinicians can take to greatly reduce the risk of development of an infection or a compromised immune system [22, 25]. These steps – actions include such items as the athlete should;

- Keep vaccine(s) administration updated
- Attempt to minimize contact with known infected or sick people
- Wash hands frequently throughout the day
- Limit mouth/nose contact when with infection symptoms (i.e. URS)
- Do not share drinks with other sportsmen
- Do not share towels or washcloths with other sportsmen
- Isolate team members from others if displaying infection symptoms
- Protect airway from very cold or dry air with performing strenuous exercise
- Maintain adequate daily dietary carbohydrate intake (~60% daily caloric intake)
- Wear proper clothing for weather conditions and avoid getting cold-wet after exercise
- Attempt to get a minimum of 7 hours sleep a night
- Avoid rapid weight loss and "crash" dieting approaches to weight loss
- Wear clothing to prevent unnecessary hazardous dermatological exposures (e.g. shower shoes)
- Whenever possible minimize other life stressors

Evidence-based findings support that following these steps can significantly decrease the risk of infections developing in athletes [23, 25]. Obviously, though it may not be completely realistic to incorporate all of the above into the daily behaviors and life-styles of every athlete.

Treatment

Even with compliance to all of the abovementioned preventative steps and actions there is always a strong likelihood that an athlete will develop an infection of some type. This occurrence would be apparent if they display such symptoms as; sore throat, coughing, runny/congested nose, muscle/joint pain – edema, headache, fever, malaise, diarrhea and vomiting [23, 25, 26]. Recently, a collection of leading exercise immunologists recommended the following course of action when sports medicine clinicians are dealing with an athlete displaying overt signs of an infection and, or inflammation [22, 25].

- Day 1 of Illness – No strenuous exercise or competition; they should drink plenty fluids; keep from getting wet/cold; minimize life-stress. If feverish – induce nasal drainage, and use decongestants-analgesics.
- Day 2 of Illness – If symptoms worsen – no exercise, rest. If no fever or worsening of symptoms; then light-easy exercise (30–45 min) allowed.
- Day 3 of Illness – If fever, symptoms persist consult physician. If no fever or worsening of symptoms; then light-moderate exercise (45–60 min) allowed.
- Day 4 of Illness – If no symptom relief, no exercise – continued rest; have an office visit with a physician. If relief (1st day of improved symptoms), and no fever, then light-easy exercise (as noted above). Use the same number days as off to return and step up to normal training; monitor tolerance to gradually increasing exercise intensity, take additional days off if poor tolerance (if necessary).

Finally, in order to optimize treatment, it is critical that all members of the health-care team treating the athlete have good communication with one another concerning the progression and responses of the athlete if symptoms develop and persist [2, 4, 10].

CONCLUSIONS

In conclusion, competitive sportsmen (and sportswomen) subject themselves to a high level of exercise training stress in order to enhance their physical performance capacity. This training stress, as well as the other stresses of life these sportsmen encounter, places them at a great risk for developing the OTS. The "cytokine tissue-trauma" hypothesis of OTS proposes that undue pro-inflammatory cytokine responses to excessive exercise training (overreaching-overtraining) creates a "sickness behavior" response, development of immunosuppression, and ultimately leads to a decline in physical performance capacity of the athlete.

It is critical that sports medicine clinicians take steps to prevent and reduce the risk of infection by helping sportsmen-women to foster and develop appropriate behaviors and actions as recommended above. Likewise, once an infection – inflammation response is manifested in the athlete it is critical for these same clinicians to take the actions to mitigate the severity and impact of the illness development through the recommended intervention steps. By doing so, the clinician can promote a more rapid return to normal health and exercise training level in the athlete.

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MOTIVATIONAL MUSIC AND REPEATED SPRINT ABILITY IN JUNIOR BASKETBALL PLAYERS

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ABSTRACT

We examined the effect of motivational music on repeated sprint ability (RSA) in a full squad of junior top national level league basketball players. Participants performed two repeated sprint tests (RSTs), with and without motivational music, at random order, during the end of the basketball season. The RST included 12 X 20 m runs departing every 20 s. There were no significant differences in ideal sprint time, total sprint time and performance decrement between RST with or without music. However, when we compared each sprint during the RST, the last two sprints (sprints number 11 and 12) were significantly faster with, compared to without, music ($p<0.01$). We conclude that music led to improved sprint performance towards the end of RST, suggesting, probably, beneficial effect mainly on aerobic components of repeated sprint ability. Therefore, music can be used during basketball training, hoping that improved training ability will convert also to better game performance.

Keywords: *aerobic, anaerobic, fitness, motivational music, repeated sprint test*

INTRODUCTION

Music is used frequently by athletes to increase motivation and improve aerobic and anaerobic performance [21]. However, while athletes report favourable subjective effects of music during training or competition (e.g. general feeling, mood, etc.), research has not always supported this notion [31]. It was suggested that the timing and type of music, the type of exercise, and the fitness level of the athlete, may all affect performance response to music [2, 26].

In recent years, the question what is the optimal music for use in sports has gained scientific interest. The term "motivational music" was defined as music that stimulates or inspires physical activity [20]. It is suggested that four factors, in hierarchical order, contribute to the psycho-physical motivational qualities of music: the natural reaction to the rhythm and tempo, the musicality (melody and harmony), the suitability of music to the socio-cultural background of the athlete, and the extra-musical associations triggered by music [31].

The majority of previous studies examined the effects of music on sub-maximal aerobic performance [8, 10, 18, 24, 25, 28, 29], and most of them reported positive effects on motivation, mood state and rate of perceive exertion (RPE) [8, 18, 25, 28]. The very few studies that examined the effect of music on supra-maximal anaerobic exercise yielded conflicting results [9, 26]. In recent years, the use of repeated sprint tests (RST) has gained popularity among coaches and athletes as a method of evaluating repeated sprint ability (RSA), that is used frequently in multi-sprint sports like soccer, basketball, and hockey [e.g., 1, 3, 23].

Thus, the aim of the present study was to evaluate the effect of motivational music on RSA in a group of junior top national league basketball players. We hypothesized that listening to motivational music during the RST will improve repeated sprint performance.

MATERIALS AND METHODS

Subjects

Twelve male late adolescent basketball players participated in the study. Anthropometric and aerobic characteristics of the participants are summarized in Table 1. Pubertal status was assessed by Tanner stage for pubic hair, and all the players were late pubertal (Tanner stage 4–5). Players were a full squad of a basketball team from the first division Israeli youth league. The players trained five days every week and competed once a week. The study was performed about a month before the end of the basketball season, when the players were assumed to be in top physical shape. Most training sessions at this time of the year were devoted to specific tactic drills and game skills with the use of balls. No resistance or aerobic training sessions were given at that time of the season. The study was approved by the institutional ethical committee. The testing procedure, but not the hypothesis of the study, were explained to the players, and a written informed consent was obtained from the players and their parents.

Table 1. Anthropometric and fitness characteristics of the study participants

	Mean ± SD
Age (years)	16±0.5
Height (cm)	185.9±0.9
Weight (kg)	75.5±6.1
Body fat (%)	10.6±1.9
VO_2 max (ml/kg/min)	50.3±4.4

Measures

Overall, the participants performed two RST's (with and without music) separated from each other by 4–5 days, at random order. Both tests were performed in the afternoon, three hours after lunch. The participants were instructed to drink 500 cc of water 30 min before each testing session. None of the participants were taking any food supplements. Each test was performed on a basketball court, using standard basketball shoes, to replicate game conditions. In order to prevent unnecessary fatigue accumulation, players and coaches were instructed to avoid intense exercise the day before each testing.

Repeated sprint tests

The RST protocol included a 12×20 m maximal run starting every 20 s. This protocol was chosen since its sprint length and rest duration mimic the typical movement pattern of players during a basketball game. Each participant performed a 20 m maximal sprint the day before the RSTs. The time of this sprint was used as a criterion score for the upcoming RSTs. In the first sprint of each RST, participants were required to achieve at least 95% of their criterion score. If 95% of the criterion score was not achieved, the participant was required to restart the RST. Accordingly, the participants were instructed by the coaches and the investigators to produce maximal effort during each sprint and to avoid pacing themselves. All subjects met the required criterion (95% of maximal speed in the first sprint) and no one had to restart the test again.

During each RST, a photoelectric cell timing system (Alge-Timing Electronic, Vienna, Austria) with an accuracy of 0.001 s linked to a digital chronoscope was used to record each sprint and rest interval time. Two sets of timing gates were used, working in opposite directions, to allow subjects to start the next run from the end point of the preceding sprint, thus eliminating the need to hurry back to a common starting point. A standing start, with the front foot placed 30 cm behind the timing lights, was used for all sprints. Timing was initiated when the subject broke the light beam. An experimenter was placed at each end of the track to provide verbal encouragement to each subject at each sprint.

Measurements

The three measures for each RST were the 20 m fastest ("ideal") sprint time (IS), the total accumulated sprinting time (TS) of the 12 sprints, and the performance decrement (PD) during each test. TS was calculated by the summation of all sprints times of each test. PD was used as an indication of fatigue and was calculated as [(TS/IS) X 100] – 100 [15]. The ideal possible total score was calculated as the best 20 m sprint time multiplied by 12. The test-retest reliability of the RST is 0.94 for total running time and 0.75 for the PD [15].

Heart rate was measured using a Polar heart rate monitor (Polar Accurex Plus, Polar Electro, Woodbury, NY) just before the beginning and immediately upon the completion of each run in each RST. RPE was determined using the modified Borg scale [5] just before the beginning and immediately upon completion of each RST.

Music selection

The music selection for the present study was based on the hierarchical four factor conceptual model [11, 19, 20], indicating that strong rhythm and fast tempo (>120 BPM), followed by the musicality, the suitability of music to the athlete's socio-cultural background, and lastly, the extra-musical associations triggered by music, contribute to the music psycho-physical motivational qualities. We selected a Western CD collection of greatest hits of all times converted to dance style with a rhythm of 32 and tempo of 140 BPM. Four tracks (numbers 3, 5, 8 &13) with accumulated time of 15 min were selected ("Freed from Desire"– Gala, 1996, "Time after Time"– Cyndi Lauper, 1984, "California Dreaming" – The Mamas and the Papas, 1965, and "Heaven" – Bryan Adams, 1983). Music was played by a stereo CD player (Sony CFD-V7). The music volume was equal to 70 decibels. Since Western music is very popular in our country, this CD is used frequently in health clubs, schools and sports colleges for aerobic training, and thus also fulfills the criteria of the music's suitability to socio-cultural background and strong association to sport. We have previously demonstrated that listening to selected tracks from this CD (ranked by the participants as a device to increase activity) during warm-up improved peak anaerobic power in elite adolescent volleyball players [13].

Statistical analysis

Paired t-test was used to determine differences in ideal sprint time, total sprint time, performance decrement, heart rate and RPE, between RST with and without music. ANOVA for repeated measurements was used to determine differences in each sprint result between RST with and without music. Data are presented as mean±SD. Significance level was set at $p<0.05$.

RESULTS

There was no significant difference in end RST heart rate between RST with (179.9±8.5 beats/min) and without music (181.4±6.3 beats/min). However, mean heart rate during the RST with music (179.4±3.9 beats/min) was significantly greater than mean heart rate during the RST without music (176.7±5.7 beats/min, $p<0.01$). There were no significant differences in end RST RPE with (7.1±0.7) and without music (7.0±1.0).

The effect of music on RST performance indices is shown in Figure 1. There were no significant differences in ideal sprint time, total sprint time and performance decrement between RST with or without music. However, when we compared each sprint during the RST, the last two sprints (sprints number 11 and 12) were significantly faster during the RST with, compared to without, music ($p<0.01$, Figure 2).

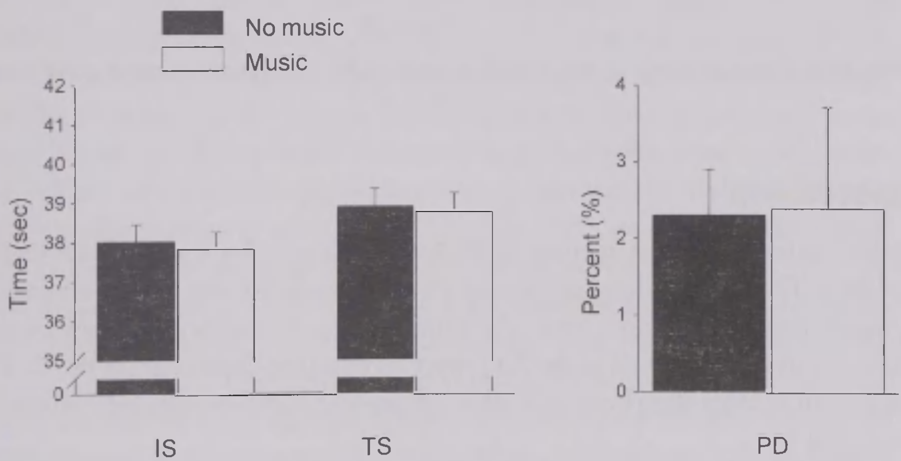

Figure 1. Effect of music on RST performance indices

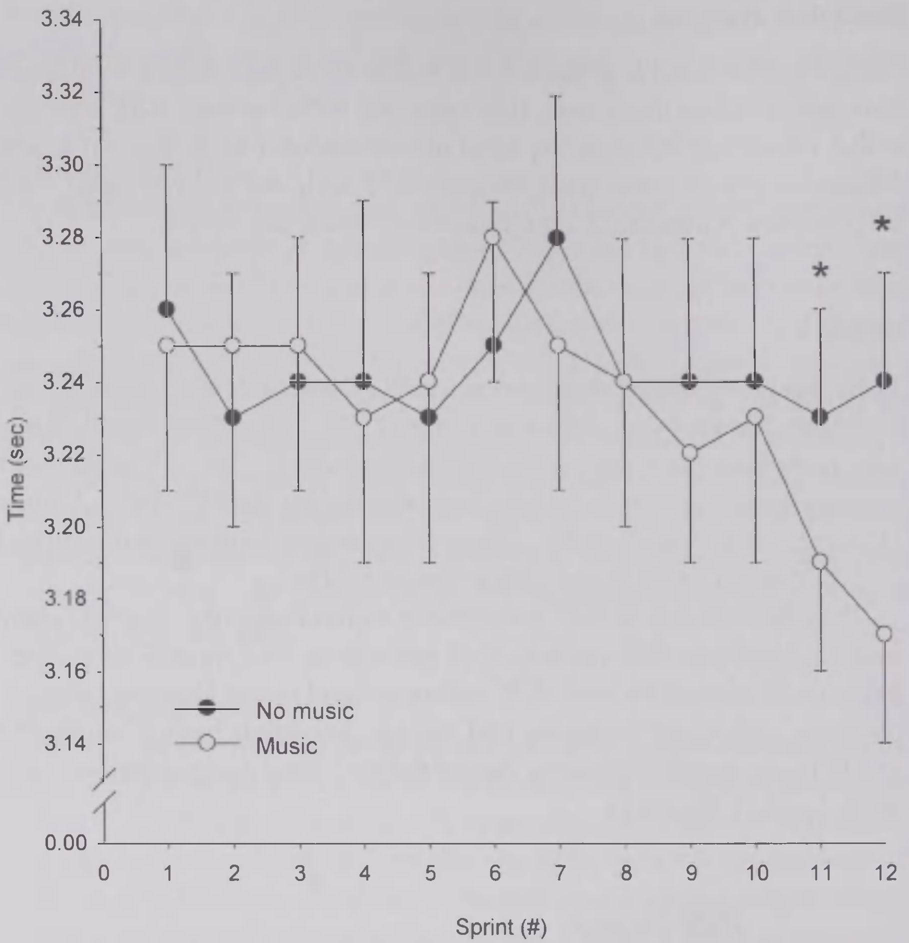

Figure 2. Effect of music on the results of each sprint during the repeated sprint test

DISCUSSION

We examined the effect of music on RSA in top national level junior basketball players. The main findings of the study were that while there was no effect of music on ideal sprint time, total sprint time and performance decrements, the last two of the 12 sprints in the RST were significantly faster during the RST with music, suggesting beneficial effect of music in high intensity intermittent exercise.

Selection of music type plays an important role in determining its effect on exercise capacity. It is generally accepted that music selection aims to optimize an individual's goal. When an athlete needs to be motivated or to remain aroused during intensive power and/or endurance exercise tasks, fast and motivational music should be selected. Usage of the same music can be detrimental for exercise that requires concentration and high level of coordination [14]. Since the aim of the present study was to test the effect of music on RSA, we selected motivational music (rhythmic with fast tempo). We hypothesized that the natural response to rhythm and tempo, and possible music-related dissociation from unpleasant feelings like pain and fatigue [31], would improve performance indices of the RST. However, in the present study music had beneficial effect only on the speed of the last two of the 12 sprints test.

As stated earlier, the majority of studies that demonstrated beneficial effects of music on exercise performance focused on sub-maximal aerobic exercise [e.g. 10, 26]. It was shown previously that the stores of phosphocreatine (PCr) are essential for the reconstitution of short-term power output during repeated exercise [4]. This is particularly relevant in RST protocols that include a high number of repetitions and a short recovery time. Indeed, PCr re-synthesis is controlled by the rate of oxidative metabolism within the muscle [30], and several previous studies have found moderate correlations between VO_2 max and performance indices of RSTs [12, 16, 22]. In the present study, music-related improvement in sprint performance was found only in the last two sprints, and not in the first sprints of the RST. Thus, one could argue that this finding emphasizes the beneficial effect of music on the more aerobic parts of the RST, and the lack of effect on the more anaerobic component of the test.

The significant beneficial effect of music on the speed in the last two sprints of the RST should not be underestimated. In competitive sports, even a small difference may distinguish between success and failure. For example, Cometti et al. [7] showed that French professional and amateur soccer players had similar 30-m sprint performance, but the professionals had significantly lower 10-m lap times. The reported 10-m sprinting times ranged from 1.79 to 1.90 s [27]. This means that faster players are on average about 1-m ahead of slower players after a sprint of only 10-m. This difference can influence the results of a game, especially at final stages when fatigue increases among the players and intensity tend to decrease. The same applies for a possible faster sprint performance of basketball players during time of fatigue in later parts of the game (e.g. fast break execution or prevention, ball stealing, etc.). However, since the present study examined effect of music *during* the exercise task on performance, the interpretation of the results is applicable only for basketball training and not to performance in a real game, when listening to music is not permitted. Hopefully, improved training performance will be converted to game performance as well.

Finally, previous reports have demonstrated that music effects are inversely related to the participant's fitness level, and that music had significantly greater enhancing effects in untrained participants, during initial stages of training programs [6, 17]. In the present study, the players were tested towards the end of the basketball season when they are assumed to be in top physical shape. It is possible that if the study was performed during earlier stages of the basketball season, when the players are less fit, music effects would have been more beneficial.

In summary, music led to improved sprint performance towards the end of RST, suggesting, probably, beneficial effect mainly on aerobic components of repeated sprint ability. Therefore, music can be used during basketball training, hoping that improved training level will translate also to better game performance. Additional studies are needed to examine the optimal selection and use of music and its role in enhancing athletic performance in young competitive athletes.

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THE ACUTE EFFECTS OF WARM-UP, STATIC AND DYNAMIC STRETCHING EXERCISES ON *BICEPS BRACHII* MUSCLE FUNCTION IN FEMALE BASKETBALL PLAYERS

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ABSTRACT

Static and dynamic stretching exercises are often used in sports before competition and training sessions. Recent studies have shown different effects of dynamic and static stretching exercises on physical performance capacity. The aim of the present study was to evaluate the acute effect of warm-up, 30 s static and dynamic stretching exercises on *biceps brachii* muscle function. Nine athletes were examined twice in different days: after performing static and dynamic stretching exercise. Isometric maximal voluntary contraction characteristics were measured using dynamometry; muscle tone, elasticity and stiffness characteristics of *biceps brachii* muscle were measured using myotonometer Myoton-3. All measurements were performed before and after the warm-up (5-min jogging with self-selected speed), immediately after stretching exercise and after 10 min rest. Warm-up did not cause any changes in the isometric maximal voluntary contraction, strength of elbow flexor muscle as well as in muscle tone and elasticity. Static stretching was effective to increase elasticity of *biceps brachii* muscle, but did not influence the isometric strength characteristics of elbow flexor muscles. Shortening of isometric contraction latency of elbow flexor muscles after dynamic stretching exercise and increase of strength after 10 min rest were noted. Therefore this type of stretching can be recommended to prepare muscles for explosive maximal exercise.

***Keywords**: static stretching exercises, dynamic stretching exercises, isometric strength, muscle stiffness, muscle tone*

INTRODUCTION

Warm-up is an essential part of sports activities helping to prepare the organism for the following exertions. Athletes use many different types of stretching that are usually based only on their personal preference, but no optimal type or amount of stretching exercises has been identified [6]. The intended purposes of stretching before an athletic event are to insure that the individual has sufficient flexibility of joints to perform the athletic activity optimally and to decrease muscle stiffness or increase muscle compliance, thereby theoretically decreasing injury risk [9]. In addition to aerobic warm-up, different kinds of stretching exercises are widely used, including ballistic, proprioceptive neuromuscular facilitation, static and dynamic stretching [6, 9]. To find out the optimal warm-up program and to select exercises which improve the contraction speed and power of muscle-tendon unit, and help to prevent injuries simultaneously are actual in sports practise. The studies of recent 10 years have not found which kind of stretching is more effective for warm-up – the static or dynamic stretching exercises. Static stretching exercises increase the joint range of motion almost two-fold as compared to dynamic stretching exercises but they have no positive effect on the muscle contraction characteristics and explosive muscle strength [1, 4, 10]. It has been also demonstrated that warm-up which includes dynamic stretching exercises is effective to prepare the muscle for performance during high-speed movements [5]. In many sports events, it is important to achieve the optimal condition of muscles in very short time, especially among the exchange players in ball games or in throwing events between the trials. In most previous studies, the function of lower limb muscles has been determined, but in several sports events the maximal exertion of upper limbs is very important. The aim of this study was to analyse the acute effect of warm-up and compare the influence of static and dynamic stretching exercises on the *biceps brachii* (BBr) muscle function in female basketball players.

MATERIALS AND METHODS

Participants

Nine healthy adult female basketball players (mean age±SE: 22.0±0.8 years, body height 1.71±0.03 m, body weight 67.9±2.34 kg) participated voluntarily in this study. Subjects had been trained for 13.6±0.9 years with a mean load 11.0±1.53 hrs per week and competed at national level. Before the beginning of the testing session, all subjects completed an informed consent form. The study carried the approval of the Ethics Committee of the University of Tartu.

Design of experiment

The subjects were evaluated twice after day of rest from training. The period between two examinations was 1–5 weeks. Each examination included two stages. The first stage was similar in both examinations: the subjects performed a warm-up (5 min jogging with individually chosen speed) after first measurements. Next 2–3 min after warm-up measurements was performed. The second stage consisted of pain-free stretching exercise for the *biceps brachii* muscle-tendon unit: in first examination 30 s of passive stretching, and in the other examination accordingly 32 s of active dynamic stretching (8 times 4-s stretching exercises). Measurements were performed immediately after the stretching and fourth measurements after 10-min rest (Figure 1).

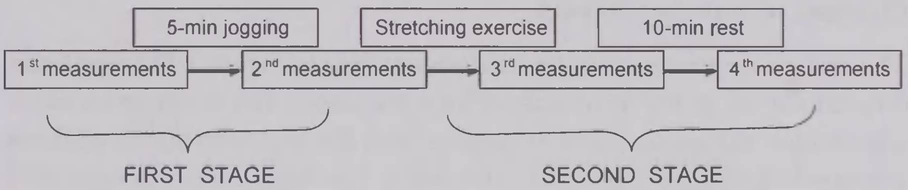

Figure 1. Design of the experiment. After first measurements the subjects jogged for 5-min and 2nd measurements were carried out. After 2nd measurements the subjects performed stretching exercise, followed by 3rd measurements. Then the subjects rested for 10 min, and finally, 4th measurements were performed.

Isometric strength measurement

The isometric maximal voluntary contraction (MVC) force of *biceps brachii* was investigated using a custom made chair and standard dynamometer. The subjects were required to perform a maximal contraction of elbow flexor muscle beginning from the switch of signal lamp on and to held the maximal exertion as hard as possible during 2 s and to relax quickly when the signal disappeared. The following characteristics of isometric strength were recorded: isometric maximal voluntary contraction force (Fmax, N), rate of peak force development (RFD) 0.2 s after the beginning of contraction, RFD at the level of 50% of MVC and the latency of contraction (LATc).

Muscle tone measurement

The stiffness (N/m) of *biceps brachii* muscle at rest was registered using myotonometer Myoton 3 (Müomeetria OÜ, Estonia) in sitting position of the subject in abovementioned chair. In present study the stiffness of the muscle is accepted as the property to resist the forces trying to change its shape [11]. To compare the relative changes, the results of first measurement on both examination days were accepted as 100% (baseline level).

Statistical analysis

Data are presented as means and standard errors of means. The Student paired *t*-test was used for comparison of groups. A level of $p<0.05$ was selected to indicate statistical significance. The data of first measurement on the both examinations were used as baseline level.

RESULTS

Changes of muscle stiffness

The changes in muscle stiffness are demonstrated in Figure 2. No significant difference in *biceps brachii* muscle stiffness was noted after warm-up on either examination day as compared to baseline level. *Biceps brachii* muscle stiffness decreased significantly ($p<0.001$) after static stretching exercise as compared to baseline level and increased after 10-min rest ($p<0.001$). *Biceps brachii* stiffness decreased also after dynamic stretching exercise but these changes did not differ significantly ($p>0.05$).

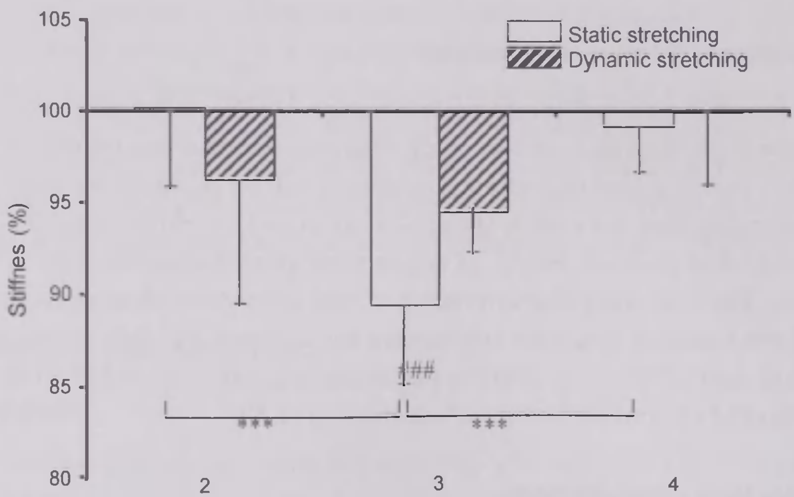

Figure 2. The changes in muscle relative stiffness after static and dynamic stretching. *** p<0.001, ### p<0.001.

Changes in strength characteristics

No significant changes in isometric maximal voluntary contraction force (MVC) were registered on either day of examinations (Figure 3A). No significant changes were found in majority of parameters of contraction force in both examinations. The significant increase of RFD $_{0.2}$ after BOTH stretching exercise ($p<0.05$) was found (Figure 3B). $RFD_{50\%}$ did not differ significantly on either examination day. After warm-up and static stretching exercise LATc did not decrease significantly. Dynamic stretching exercise caused the significant shortening of LATc as compared to baseline level ($p<0.05$) and to warm-up ($p<0.01$). After the 10-min rest LATc prolonged significantly as compared to after stretching ($p<0.01$) (Figure 4).

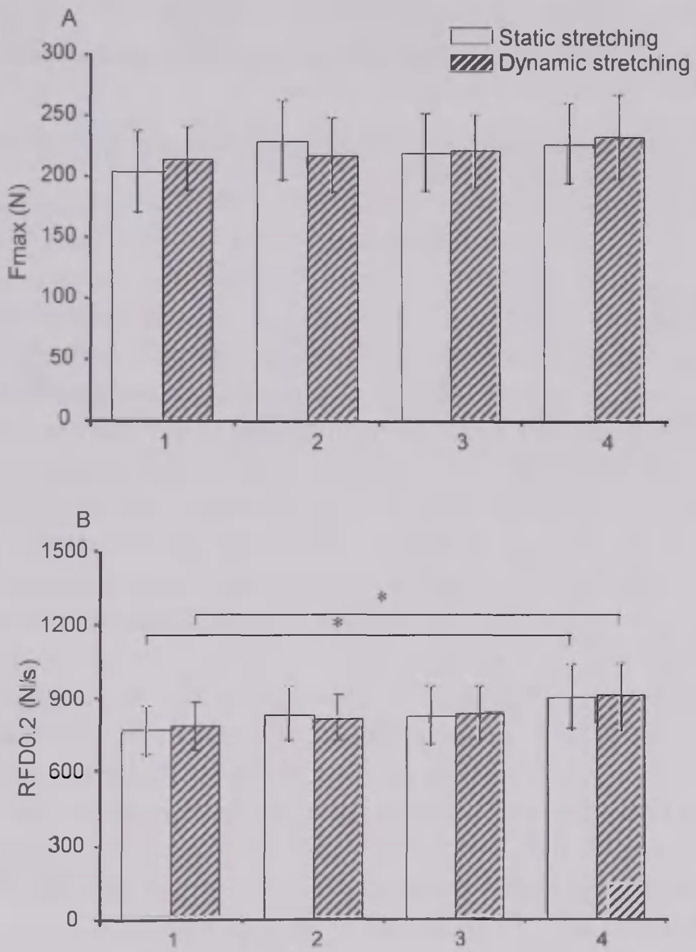

Figure 3. A: The changes in isometric maximal voluntary contraction force (mean±SE). B: The changes in RFD0.2 (means ± SE). *p<0.05

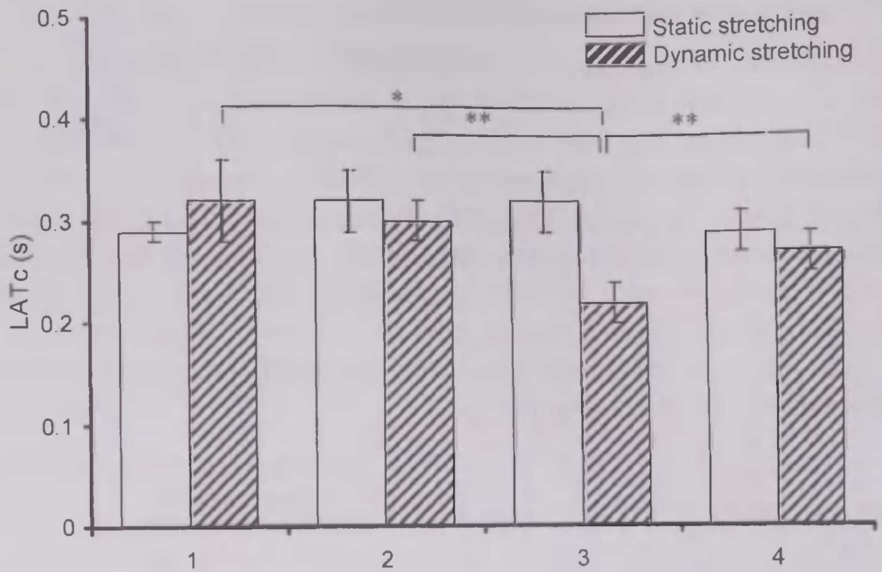

Figure 4. The changes in latency of contraction after static and dynamic stretching (LATc) (mean±SE). $^{*}p<0.05$, $^{**}p<0.001$.

DISCUSSION

In the present study, a comparison of the acute effect of different type of stretching exercises on the function of *biceps brachii* muscle in female basketball players was performed. The main finding of our study was that the muscle tone characteristics, expressed as muscle stiffness, decreased significantly after static stretching exercise but not after dynamic stretching exercise. Neither static nor dynamic stretching exercise had significant influence on isometric maximal voluntary contraction force generation. Latency of MVC shortened significantly after dynamic exercise as compared to baseline level. Several authors confirm that warm-up helps to achieve the quicker spread of the nerve impulse [5]. Pearce et al. [7] demonstrate that the improvement of neuromuscular electrical conduction has been caused by the better electrical conduction of contractile apparatus and muscle fibers. The electrical conduction increases during warm-up in both active and passive skeletal muscles [7]. Our results are not in full accordance with abovementioned findings, because we did not find significant changes of LATc immediately after stretching on both examination days.

The stiffness of *biceps brachii* muscle decreased after 30 s of static stretching but after 10-min rest did not differ from the baseline level. This finding can be explained by mechanical theory which states that impairment of muscle stiffness leads to the decrease of force, because the optimal distance between actin and myosin filaments is disturbed causing changes in force production [3]. We did not find the decrease in force production accompanied by a decrease of stiffness in our experiment. In contrary to our results, previous study did not demonstrate changes in muscle stiffness after static stretching exercise [2]. The duration of stretching exercise can be the reason of different results among these studies. In many experiments, the repeated series of static stretching have been used and therefore the duration of static exercise lengthens. The results of Yamaguchi and Ishii [12] are in accordance with ours: 30 s static stretching had no significant effect on the force parameters in their study [12].

It is well known that dynamic stretching increases the intramuscular temperature [8]. We did not measure the intramuscular temperature in our experiment but it can be assumed that increased temperature could cause the shortening of LATc [8]. LATc decreased significantly after dynamic stretching exercise – its values were 31% lower than baseline level and 27% lower than after warm-up. After 10 min rest LATc was recovered to the control level ($p<0.01$). Many sports events require movements including dynamic stretching and therefore it can be supposed that using of dynamic stretching in training could increase the effectiveness of movements [5]. As the co-effect of warm-up program and rest, $RFD_{0.2}$ increased after BOTH stretching exercise. This can be explained with the cumulative effect of all manipulations.

We can conclude that 5 min warm-up and following static stretching exercise of *biceps brachii* muscle decrease the muscle stiffness for 10 min more as compared to dynamic stretching exercise. At the same time, the force generation capacity of elbow flexor muscles and the latence time of contraction generation capacity did not change significantly. The latence time of muscle contraction decreased as a result of warm-up and following dynamic stretching. Explosive strength of elbow flexor muscles increased significantly after warm-up and dynamic stretching as well as after 10 min rest which demonstrates the positive co-effect of these activities on the contractile capacity of skeletal muscle. The dynamic stretching exercises can be recommended to prepare the muscles for maximal exertions.

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THE IMPACT OF LOW INTENSITY SPECIFIC AND NONSPECIFIC STRENGTH-ENDURANCE TRAINING ON SUBMAXIMAL WORK CAPACITY IN TRAINED MALE ROWERS

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ABSTRACT

The aim of the current study was to compare the effects of general strength endurance and specific strength endurance training cycle to rowing performance in highly trained male rowers. Twelve international and national level male rowers (21.25±1.76 years; height 188.3±4.92 cm; body mass 84.07±5.61 kg; training experience 7.38±2.70 years) took part in this investigation. The first group (n=6) performed low intensity strength endurance trainings using rowing ergometer for specific exercises (Specific group; S), and the second group (n=6) trained for strength endurance without rowing ergometer (Gym group; G). The experimental period lasted for four weeks. Stepwise incremental test was performed on the Concept II rowing ergometer (Morrisville, USA) before the first training week. After incremental ergometer test, subjects performed a constant 95% of Pa max test until exhaustion. This test was done 24 hours after incremental test and was performed before Week 1 and after Week 4. The stroke rates of the 95% Pa max test were not significantly different ($p>0.05$) between the two groups during both testing sessions. Despite the fact that both groups improved their 95% Pa max test results, no significant differences between the groups were found ($p>0.05$). However, test result was significantly improved only in G group (from 362±108 to 416.5±133 s), while no significant changes were observed in 95% Pa max test result in S group (from 372.8±132.3 to 442.3±153.1 s). No other significant differences were observed either between the two groups or between the two testing sessions ($p>0.05$). In conclusion, a 4 week non-specific strength endurance training program has an advantage over the specific strength endurance training on rowing ergometer in developing aerobic capacity in male rowers.

Keywords: *strength endurance, rowing, aerobic performance, strength training*

INTRODUCTION

Rowing is a strength endurance type of sport where aerobic and strength capacities play an important role in achieving a maximal result on the classical 2000 meter distance. This might cause timing problems, since not all capacities can be developed simultaneously [19]. For rowers it is very important to include strength endurance trainings in addition to aerobic trainings into annual training plan [3]. During the preparatory period, that usually starts in November, the total amount of aerobic trainings can vary from approximately 90% of the whole training time [7, 17] to 99% of the total training volume [13]. During endurance workout muscles do thousands of contractions at relatively low contraction force, while during strength and power training only few contractions at very high intensity are done. Therefore, those two concepts cannot be trained simultaneously. Moreover, the influence of maximal strength and power training is mainly on fast twitch fibres, while the effect of strength endurance training is mainly on slow twitch fibres [3].

It has also been argued that if the performance of the athlete increases, more time should be devoted to specific training in comparison with general training [8, 15]. Boland and Hosea [6] have also argued that strength training should be focused as close as possible to the movements a rower does in the boat. Strength endurance at low speeds should have the main effect on slow-twitch muscle fibres, while strength and power training focus on fast-twitch fibres [19]. However, it has been found that power training at low resistance causes lactate concentration to raise 5.00±1.2 mmol/L, while power training at high resistance causes lactate to rise to 6.35±1.7 mmol/L [19]. However, there are no data in the literature that have studied the training effect of low intensity, high volume strength endurance training to rowing performance, while lots of data exists on the development and maintaining of strength capacities. For example, Bell et al. [1] have investigated whether strength training at high or low speeds has the influence on anaerobic power and maximal strength. The first group in that study did power exercises at 40% RM and 18–22 reps, the second group did 6–8 sets of maximal strength at low speeds and the third group did only endurance training at low intensity. The results showed that the only group that improved performance was the endurance training group. However, no data exists in the literature of the effect of a strength endurance training cycle to rowing performance.

The aim of the current study was to compare the effects of the general strength endurance and specific strength endurance training cycle to rowing performance in highly trained male rowers.

MATERIALS AND METHODS

Subjects

Twelve international and national male rowers (21.25±1.76 years; height 188.3±4.92 cm; body mass 84.07±5.61 kg; training experience 7.38±2.70 years) took part in this investigation (Table 1). Subjects were healthy and were not taking any medicine during the study period. All subjects were informed about the study procedures before signing a written informed consent to participate in the study.

Procedures

The investigation took part at the beginning of the preparatory period (i.e. from the end of October) and lasted for four weeks. This training period can be characterized as a period of low intensity and high volume, with most of the trainings done below aerobic threshold. The subjects were divided into two groups using matched pair design. The first group (n=6) performed low intensity strength endurance trainings using rowing ergometer for specific exercises (Specific group; S), and the second group (n=6) trained for strength endurance without rowing ergometer (Gym group; G). The used exercises were with similar volume and intensity for both groups, however in S group rowing ergometer was used for leg press, arm pull, snatch, power clean, etc. Training volume during the first week (Week1) was 593.3±5.66 min, for the second week (Week2) 630.7±5.61 min, for the third week (Week 3) 670.4±6.12 min and for the fourth week (Week 4) 586.6±7.46 min in both groups. Additionally, both groups trained about 8% of the whole training time in single sculls, 22% of the training time was biking or running, and approximately 30% of the whole training time were strength endurance trainings, with 40% 1 RM at 17 times per minute rate. Athletes trained 7 times per week, with one day of full rest.

Table 1. Anthropometrical and physiological parameters (mean±SD) of the subjects according to the study group

Parameter	S group	G group
Height (cm)	185.5 ±3.3	191.1 ±4.7*
Body mass (kg)	82.7 ±6.8	85.3 ±4.3
Training experience (years)	7.5 ±3.0	7.3 ±2.6
VO_{2max} (L/min)	5.1 ±0.58	5.5 ±0.33
VO_{2max} (w)	348 ±38.1	367 ±33.6

Note: S – specific training group, G – general training group, *significantly different from S group, $p<0.05$

Incremental test on rowing ergometer

Stepwise incremental test was performed on the Concept II rowing ergometer (Morrisville, USA) before the first training week. The subjects were asked not to participate in any physical activity exercises during the previous 24 hours preceding the test. The test started at 150 W and was increased after every three minutes by 50 W until volitional exhaustion. Heart rate (HR) was measured continuously throughout the test using a commercially available HR monitor (Polar S725X, Polar Electro, Finland). During the test maximal oxygen consumption and the corresponding power (maximal aerobic power; Pa max) were calculated. The following formula was used to calculate Pa max:

$$\text{Pa max} = P1 + P2 \times T/180, \text{ where:}$$

P1 was the load that was previous to the load, where maximal oxygen consumption occurred. In case maximal oxygen consumption occurred at the end of the stage, then Pa max equalled the power of the stage; P2 was the increase of the load (50 W); and T was the time in seconds of the last stage.

Submaximal intensity tests

After incremental ergometer test, subjects performed a constant 95% of Pa max test until exhaustion. This test was done 24 hours after incremental test and was also performed before Week 1 and after Week 4. The subjects were not allowed to any moderate or vigorous activity 24 hours before the test. Both continuous intensity tests were held between 10–12 am and testing time was kept constant for each subject. A standardized warm-up at the intensity of 50% Pa max for 20 minutes was performed. To increase the objectivity of the tests, the subjects did not see the time nor stroke rate from ergometer display. However, they were verbally encouraged to achieve maximal result. During the test time, average power, covered distance and average stroke rate were registered.

Statistical analysis

A statistical package SPSS for Windows was used. Descriptive parameters (mean±SD) were calculated. The differences between the variables were calculated using paired-T tests, as data was normally distributed. The statistical significance was set at ($p<0.05$).

RESULTS

Changes in training volume during the four week period increased significantly during Week 2 and 3 and then decreased significantly during Week 4 (Figure 1).

Descriptive parameters of the incremental test, maximal aerobic power and anaerobic threshold indices are presented in Table 2. No significant differences between the parameters were seen between the two studied groups, except the height of the G group was significantly lower (191.1±4.7 and 185.5±3.4 for S and G groups, respectively).

Table 2. The results of the incremental rowing ergometer test (mean±SD) of the subjects according to the study group

Parameter	Total	S	G
VO_{2max} (L/min)	5.32 ±0.50	5.13 ±0.58	5.5 ±0.33
$VO_{2/kg}$ (mL/min/kg)	62.8 ±6.94	62.3 ±8.66	63.2 ±5.53
P_{max} (w)	376.7 ±25.34	373.3 ±16.33	380 ±33.46
Pa_{max} (w)	357.6 ±35.32	348.7 ±38.18	366.5 ±33.2
V_E (L/min)	188.8 ± 21.75	182.1 ±25.69	195.4 ±16.58

Note: S – specific training group, G – general training group

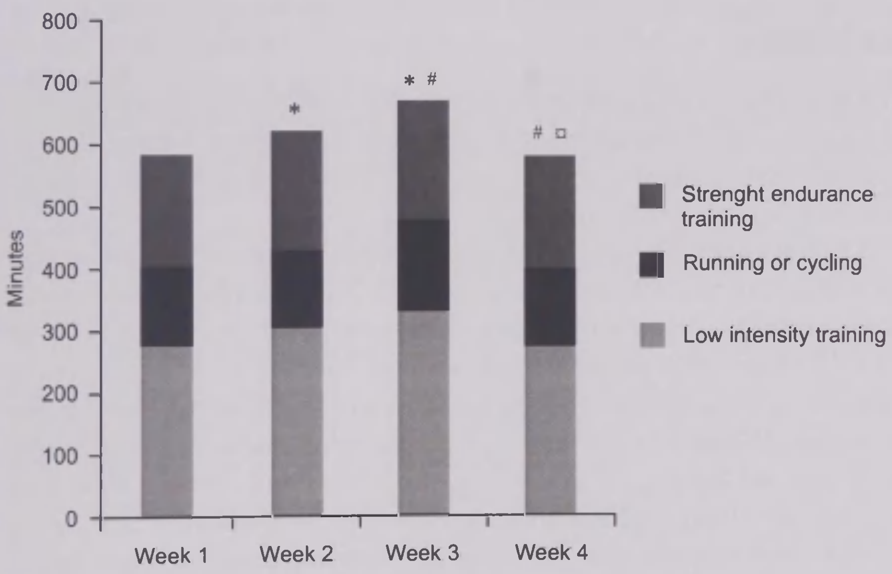

Figure 1. Training volumes during the 4 week study period in both groups. *significantly different from week 1, #significantly different from week 2, □significantly different from week 3.

Stroke rates during the 95% Pa max test were not significantly different ($p<0.05$) between the two groups during both testing sessions (Table 3). Despite the fact that both groups significantly improved their 95% Pa max test result, no significant differences in performance between the groups were found ($p>0.05$). However, 95% Pa max test result was significantly improved only in G group (from 362±108 to 416.5±133 s), while no significant changes were observed in 95% Pa max test result in S group (from 372.8±132.3 to 442.3±153.1 s). No other significant differences were observed either between the two groups or between the two testing sessions ($p>0.05$).

Table 3. The results of the 95% Pa_{max} test according to the study group

Parameter	S before 4 weeks	S after 4 weeks	G before 4 weeks	G after 4 weeks
Distance (m)	1815±627	2150±698	1752±512.9	2060±620.8*
Time (sec)	372.8±132.3	442.3±153.1	362±108	416.5±133.7*
Stroke rate (s/m)	30.8±1.7	29.5±1.5	30±1.6	29.33±1.96
Average power (W)	332.3±38.4	332.3±35.8	345.83±31.6	346.6±30.5

Note: S – specific training group, G – general training group. *Significantly different from before 4 week training period ($p<0.05$)

DISCUSSION

The main result of the present study was that strength endurance trainings in the gym have significantly higher impact to submaximal rowing capacity (95% of maximal aerobic power) compared to strength endurance trainings performed on the rowing ergometer.

The aerobic energy source is approximately 70–80% of the total energy needed during the 2000 m rowing race [10, 11]. Therefore, low intensity aerobic trainings below aerobic threshold and strength endurance trainings are for the basis of the preparatory phase of the rowers [19]. A very important aspect is the intensity of the training to ensure an adaptation from one side and to prevent athletes from overtraining from the other side [16]. In the current study the used training cycle was designed to develop a strength endurance with similar training loads that were used before in the literature [1, 3, 4], being however lower than the loads that have been found to be relatively stressful and might lead to excessive fatigue [15, 18]. Therefore, we did not intend to use too high increases in training volume that could have negative influence on performance. For example, Lehmann et al. [12] have found that sudden increases in training volume might result in higher fatigue compared to increases in training intensity. Similarly, Rämson et al. [18] have found that increases in training volume for 50% during 4 weeks resulted in decreases in aerobic performance.

The results of our study indicate that low intensity trainings to develop strength endurance in gym resulted in significant increase of the 95% Pa max performance, while similar trainings using high resistance exercises on rowing ergometer resulted in no change in aerobic performance. Previous studies [3, 19] indicated that low intensity resistance trainings have negative influence on rowing performance compared to specific high tempo trainings. These discrepancies might be explained by the use of different performance test. In the current study, the performance test had mainly aerobic component, while Steinacker et al. [19] used maximal performance test, where a significant amount of energy comes from anaerobic sources. The intensity of the current test was chosen because during maximal tests, the result of the test depends highly on the motivation of the athlete [9, 14] and therefore the test result can be more easily manipulated. Using a fixed test load on the other side allows the athletes to perform at similar intensities. However, the negative aspect of constant load test is its weak similarity to real-life performance. According to the literature we can, however, conclude that 95% Pa max test is very highly related to 2000 meter rowing ergometer performance [11, 20].

The hypothesis of the current study was that specific rowing ergometer is more advantageous in order to improve 95% Pa max performance in male rowers, as the nature of the movements, muscle contractions and coordination are more similar to rowing compared to strength exercises in the gym that the other group used. Some authors have argued that strength endurance exercises did not change significantly power and changes in performance are rather the result of the specific endurance trainings [1, 2, 19]. In our study we found significant changes in the covered distance ($p<0.05$) and performance time in 95% Pamax test, while no changes were observed in stroke rate and average power (see Table 3).

The non-significant improvement in S training group might be caused by the exercises used as there was no previous experience in designing strength endurance training program on a rowing ergometer. Furthermore, to our best knowledge no references in the literature are currently available. One possible cofounder might have been a relatively high overall performance level of the subjects and because of that, a 4-week training cycle might have been too short to detect significant changes in performance. Another limitation might also be that training loads were not individually manipulated, but were similar to all the athletes in the group. However, at least two of the subjects complained for higher feelings of fatigue after the 4-week training program. Bell et al. [3] have found that general strength parameters can be maintained if at least two strength trainings per week are performed in addition to aerobic trainings. Therefore, the amount of the three strength endurance sessions per week would have been also higher in order to stimulate adaptive processes more effectively. For example, Bell et al. [1] found significant changes in endurance trained group after 5 weeks of trainings. However, the studies of Bell et al. [1, 3, 4] did not give any indication of the used training loads, but rather the used training cycles.

It has also been found previously that rowers should decrease low tempo strength endurance trainings and increase high speed power trainings during off season period [9]. During this period it is of importance to use exercises that are close to the specific movements in the boat (i.e. using the same tempo and intensity). Contrary, it has also been found that low tempo strength endurance trainings helps to increase the power during the first phase of the rowing stroke [4]. Additionally, low intensity strength endurance trainings will not cause accumulation of waste products like lactate and carbon dioxide [5] in the organism that in long term can lead to sympathetic stress.

In conclusion, a 4-week non-specific strength endurance training program has an advantage over the specific strength endurance training on rowing ergometer in developing aerobic capacity in male rowers.

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BONE MINERAL DENSITY AND HORMONAL STATUS IN ADOLESCENT ATHLETIC GIRLS

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ABSTRACT

The aim of this study was to determine the relationships of bone mineral density (BMD) and content (BMC) with selected fasting hormones in adolescents with different exercise training patterns. The participants were female athletes of weight-loaded (n=23) and weight-supported (n=24) sports, and 33 non-athletic girls aged 13–15-years. BMD (g/cm^2) and BMC (g) at the femoral neck (FN) and lumbar spine (LS) were measured. Venous blood samples were drawn to determine the concentration of insulin-like growth factor-1 (IGF-1), IGF binding protein-3 (IGFBP-3), estradiol, visfatin, adiponectin, leptin, insulin, and glucose. After adjusting for age, height, and body mass, the relationships of BMD variables with IGF-1, IGF-1/IGFBP-3 molar ratio, estradiol, and leptin levels remained significant only in the weight-loaded sport group (r=0.41–0.60; $p<0.05$). Adiponectin was inversely correlated to FN and LS BMD and BMC (r=–0.47–0.62; $p<0.05$) in weight-supported sport group only, but after adjustments for age, height, and body mass, these associations disappeared. In this study, concentrations of visfatin, a fairly new adipocytokine, were not related to bone parameters in adolescent girls with different training patterns.

Keywords: *bone health; insulin-like growth factor-1; estradiol; adipocytokines; adolescent female athletes*

INTRODUCTION

Bone is a unique, metabolically active tissue that undergoes a continuous remodelling throughout its life cycle. A great number of factors influence the accumulation of bone mineral in humans. Some are endogenic, such as heredity, ethnicity, gender, or endocrine status; the others – exogenic, such as nutrition or physical activity [12, 23]. Bone mineral is substantially accrued throughout childhood and puberty through the concerted influences of growth and systemic hormones [15]. In girls, bone development may be especially promoted by the increase of estrogen and free, biologically active insulin-like growth factor-1 (IGF-1) levels which occurs at the time of menarche and peak bone mineral accrual velocity, corresponding to ages of 11.5–13.5 years [15]. Evidence exists that several adipocytokines may also have a positive influence on bone mineral density (BMD) of the growing skeleton [8]. Visfatin, adiponectin, and leptin, the cytokine-like hormones, are suggested to carry signals from adipose tissue to bone and contribute to the relationship between fat mass and BMD [10, 11, 14, 27].

It is well known that mechanical loading activity on bone is vitally important for skeletal strength and development. Maximizing BMD and bone mineral content (BMC) during the growing years by adopting weight-bearing physical activity in childhood and adolescence may be one of the most effective osteoporosis prevention strategies [7]. Adolescents engaged in weight-bearing sports (such as gymnastics) appear to achieve significantly greater regional and whole-body gains in bone mineral than adolescents involved in weight-supported activities (such as swimming) [9]. The nature of the sport may affect bone mineralization in adolescent athletes due to a relative state of energy deficiency and changes in body fat mass [17]. Evidence suggest that bone health can be compromised if IGF-1 and estrogen levels are low, particularly in those young female athletes who participate in competitive sports where leanness may be emphasised or aesthetically pleasing (i.e. gymnasts or swimmers) [1, 29]. Nevertheless, Courteix et al. [5] suggested that physical activity has beneficial effects on bone that may counterbalance such negative factors of bone health such as low fat mass and insufficient blood leptin levels in adolescent females.

The possible synergism between advancing pubertal status and loading induced bone gain suggests that a "window of opportunity" for bone response may exist in early puberty [15]. However, little information is available concerning the relationships between bone parameters and fasting hormones, especially different adipocytokines, in adolescent female athletes. The aim of this study was to determine the relationships of BMD and BMC with IGF-1, IGF binding protein-3 (IGFBP-3), estradiol, and selected adipocytokines (visfatin, adiponectin, and leptin) in adolescent girls with different training patterns.

MATERIALS AND METHODS

Subjects

In total, 80 healthy 13–15-year-old girls from different schools and sport clubs in Estonia (Tallinn, Tartu, Pärnu) took part in this cross-sectional study. Before entering the study, volunteers completed simple medical and physical activity questionnaires to provide information such as the onset of the training and weekly hours of participating in sports. All participants were free from past or present diseases known to affect skeletal metabolism. None of the girls used birth control or medications known to affect bone. Girls were also asked not to change their eating habits [13]. The participants comprised three groups: athletes of weight-loaded (rhythmic gymnastics; n=23) and weight-supported (swimming; n=24) sports, and 33 nonathletic healthy girls (untrained controls). The athletic girls must have participated in their selected sports for at least for the last two years (Table 1). Control group girls only took part in compulsory physical education classes at school (i.e. 45 min twice per week). Each girl and her parent (or legal guardian) received a full written description of the nature of the study and signed an informed consent form before participating. The study was approved by the Medical Ethics Committee of the University of Tartu (Estonia).

Measures

Body height and sitting height were measured to the nearest 0.1 cm using the Martin's metal anthropometer. Body mass was measured to the nearest 0.05 kg using medical scales (A&D Instruments Ltd, Abingdon, UK). The girls were dressed in light clothing and wearing no shoes. Body height and body mass data were used to calculate body mass index (BMI) (kg/m^2). The determination of years from the attainment of peak height velocity (PHV) – an indicator of somatic maturity, reflecting the maximum velocity in statural growth during adolescence – was used to assess physical maturity of the participants [2]. Predicted age at PHV (APHV) and biological maturity age (how many years a girl was from APHV) of the participants was estimated using chronological age, body height, sitting height, and body mass data (the predictive equation may be accessed at http://taurus.usask.ca/growthutility/ using one of the Childhood Growth Utility Programs developed by members of the Saskatchewan Childhood Growth and Development Research Group based in the College of Kinesiology, at the University of Saskatchewan, Saskatoon, Saskatchewan, Canada) [2]. The girls were also asked if they had experienced menarche. The data on the age at menarche and the duration of a single menstrual cycle of the girls was obtained using a simple questionnaire.

BMD (g/cm^2) and BMC (g) at femoral neck (FN) and lumbar spine (L2-L4) (LS) were measured by dual-energy X-ray absorptiometry (DXA) using the DPX-IQ densitometer (Lunar Corporation, Madison, WI, USA) equipped with proprietary software, version 3.6. DXA measurements and results were evaluated by the same examiner. Coefficients of variations (CVs) for BMD and BMC measurements in female adolescents were less than 2%.

Venous blood samples to determine the concentration of IGF-1, IGFBP-3, estradiol, visfatin, adiponectin, leptin, insulin, and glucose were drawn between 07:30 and 08:30 a.m. after an overnight fasting. For those girls who had regular menstruation, the fasting blood samples were drawn in the early follicular phase of the menstrual cycle, i.e. days 5–7 after menstrual bleeding started [13]. The levels of IGF-1, IGFBP-3, estradiol and insulin concentrations were analyzed on Immulite 2000 radioimmunoassay (DPC, Los Angeles, CA, USA). The intra- and inter-assay CVs for IGF-1, IGFBP-3, and estradiol were <7%. The intra- and inter-assay CVs for insulin were <5% and <12%, respectively, at an insulin concentration of 6.6 μIU/mL. The levels of visfatin and adiponectin concentrations were analyzed using ELISA kits (AdipoGen and Mediagnost, Aspenhaustr, Germany). The intra- and inter-assay CVs for visfatin were <10% and <8%, and for adiponectin – <5% and <6%, respectively. For leptin concentration an ELISA sandwich (DRG Instruments GmbH, Marburg, Germany) analysis was used. The intra- and inter-assay CVs were <7% and <12%, respectively. Glucose concentration was measured with a commercial kit (Boehringer, Mannheim, Germany) that employed the hexokinase/glucose-6-phosphate dehydrogenase method. In addition, the IGF-1/IGFBP-3 molar ratio was calculated as it is suggested to be an indirect indicator of free IGF-1 [22]. The molar ratio was obtained as follows: IGF-1(ng/mL) x 0.130/IGFBP-3 (ng/mL) x 0.036 [18]. In addition, the insulin resistance index was calculated using homeostasis model assessment (HOMA): fasting insulin (μIU/mL) x fasting glucose (mmol/L)/22.5 [16]. The greater HOMA values indicate the greater level of insulin resistance.

Statistical analysis

Standard statistical methods were used to calculate means and standard deviations (±SD). Normality of parameters was controlled by one sample Kolmogorov-Smirnov test. Statistical comparisons between the groups were made using analysis of variance (ANOVA) and Tukey *post hoc* test. Pearson product moment correlation coefficients were computed to evaluate the relationships between bone mineral values and measured blood hormones. Partial correlation analysis was performed to assess these relationships while controlling for age, height, and body mass [26]. The effect of hormonal parameters to the BMD and BMC was analysed by stepwise multiple regression analysis.

Statistical significance was set at p<0.05 and all analyses were performed using SPSS 15.0 package for Windows (Chicago, IL, USA).

RESULTS

The physical characteristics of adolescent girls with different training patterns are presented in Table 1. Although athletes of weight-supported sport (i.e. swimmers) significantly differed from the athletes of weight-loaded sport (i.e. rhythmic gymnasts) and non-athletic girls in respect to the chronological age and predicted age at PHV, no significant differences were found in biological maturity between the studied groups. FN BMD was significantly greater of girls in weight-loaded sport group compared to weight-supported sport and non-athlete groups. No significant differences were found in BMC values between the studied groups. Girls of the weight-loaded sport group had trained significantly more years than those in the weight-supported sport group (p<0.05). No significant differences were found in blood biochemical parameters among the athlete and control groups (Table 2).

Table 1. Anthropometric, biological maturation, bone mineral values, and training history in adolescent girls with different training patterns (mean±SD)

	W-L athletes n=23	W-S athletes n=24	Non-athletes n=33
Age (yrs)	14.3 ±1.0	13.7 ±1.2§	14.2 ±1.1
Body height (cm)	163.8 ±6.7	164.2 ±6.8	163.3 ±6.5
Body mass (kg)	52.4 ±8.9	55.4 ±9.2	55.2 ±8.1
BMI (kg/m²)	19.4 ±2.4	20.5 ±2.9	20.6 ±2.4
Predicted APHV (yrs)	12.4 ±0.5	12.0 ±0.4§	12.3 ±0.4
Biological maturity age (yrs)	1.9 ±0.9	1.7 ±1.0	1.9 ±0.9
Girls having menses [n (%)]	13 (56.5)	13 (54.2)	29 (87.9)
Menarcheal age (years)*	13.0 ±0.7	12.5 ±0.8	12.5 ±0.8
BMD femoral neck (g/cm²)	1.13 ±0.15#	1.01 ±0.11	1.01 ±0.11
BMD lumbar spine (g/cm²)	1.12 ±0.11	1.08 ±0.13	1.08 ±0.13
BMC femoral neck (g)	4.9 ±0.7	4.6 ±0.7	4.7 ±0.7
BMC lumbar spine (g)	44.5 ±8.2	41.6 ±9.9	41.4 ±7.9
Years of training	6.5 ±1.8	4.8 ±1.5†	–
Training duration (h/week)	9.6 ±4.9	9.4 ±3.2	–

Note: W–L – weight-loaded sport: W–S – weight-supported sport; BMI – body mass index; APHV – age at peak height velocity: BMD – bone mineral density; BMC – bone mineral content. *Of the girls that have experienced menarche. §Difference from weight-loaded sport athlete and non-athlete groups; p<0.05. #Difference from weight-supported sport athlete and non-athlete groups; p<0.05. †Difference from weight-loaded sport athletes; p<0.05.

Table 2. Blood biochemical parameters in adolescent girls with different training patterns (mean±SD)

	W-L athletes n=23	W-S athletes n=24	Non-athletes n=33
IGF-1 (μg/L)	443.2±104.9	463.7±138.6	419.2±144.9
IGFBP-3 (mg/L)	6.0±0.7	5.9±0.7	5.8±0.9
IGF-1/IGFBP-3 molar ratio	0.27±0.06	0.28±0.07	0.26±0.07
Estradiol (pmol/L)	67.7±35.2	108.0±91.4	103.1±134.5
Visfatin (ng/mL)	0.92±0.94	0.77±0.76	0.66±0.79
Adiponectin (μg/mL)	14.1±6.0	13.1±6.2	16.0±7.0
Leptin (ng/mL)	7.8±5.5	11.4±9.5	8.6±8.0
Insulin (μIU/mL)	5.6±3.2	5.0±3.5	6.0±3.5
Glucose (mmol/L)	4.9±0.3	4.9±0.4	4.8±0.3
HOMA	1.22±0.73	1.09±0.73	1.31±0.79

Note: W–L – weight-loaded sport; W–S – weight-supported sport; IGF – 1-insulin-like growth factor-1; IGFBP-3 – IGF-binding protein-3; HOMA – homeostasis model assessment

Significant correlations were found between IGF-1, IGF-1/IGFBP-3 molar ratio and both FN and LS BMD ($r=0.39–0.59$; $p<0.05$) in weight-loaded sport athletes and controls, but after adjusting for age, body height, and body mass, the relationships remained significant ($r=0.46–0.52$; $p<0.05$) only in the athlete group (Table 3). Similar trends were revealed regarding BMC values: the levels of IGF-1 and IGF-1/IGFBP-3 molar ratio were correlated with both FN and LS BMC ($r=0.38–0.52$; $p<0.05$) in non-athletes' group, but after adjustments were applied these relationships ceased to exist (data not shown). The relationships between IGF-1, IGF-1/IGFBP-3 molar ratio and FN BMC were significant ($r=0.67–0.77$; $p<0.05$) in the weight-loaded sport athlete group even after adjusting for age, body height, and body mass (data not shown). BMD values also correlated to estradiol levels ($r=0.45–0.60$; $p<0.05$), but in weight-loaded sport athlete group only. After adjusting for age, body height, and body mass, the associations remained significant ($r=0.53–0.60$; $p<0.05$). Visfatin concentrations were not correlated with FN nor LS BMD in any group ($p>0.05$). Adiponectin was found to be inversely related ($p<0.05$) to FN BMD ($r=–0.48$) and LS BMD ($r=–0.60$) in the weight-supported sport athlete group, however these relationships disappeared after controlling for age, body height, and body mass (Table 3). Leptin concentrations positively correlated with FN and LS BMD ($r=0.43–0.52$; $p<0.05$) in the weight-loaded sport athlete group only, even after adjustment for age, body height, and body mass ($r=0.41–0.63$; $p<0.05$). Similarly, no correlations were found between visfatin and BMC values in any of the studied groups; the inverse correlation of adiponectin with FN and LS BMC ($r=-0.47-0.62$; $p<0.05$) in weight-supported group disappeared after controlling for age, body height, and body mass; and leptin concentrations positively correlated with FN BMC ($r=0.56$; $p<0.01$) in the weight-loaded sport athlete group only, even after adjustment for age, body height, and body mass (data not shown).

Table 3. Pearson correlation for BMD and hormonal variables in athlete and non-athlete groups. Partial correlation analysis (controlled for age, body height, and body mass) is presented in parenthesis

	W-L athletes n=23	W-S athletes N=24	Non-athletes n=33
BMD femoral neck (g/cm²)			
IGF-1 (μg/L)	0.59** (0.52*)	NS	0.54** (NS)
IGFBP-3 (mg/L)	NS	NS	NS
IGF-1/IGFBP-3 molar ratio	0.52* (0.46*)	NS	0.57** (NS)
Estradiol (pmol/L)	0.60** (0.60**)	NS	NS
Visfatin (ng/mL)	NS	NS	NS
Adiponectin (μg/mL)	NS	−0.48** (NS)	NS
Leptin (ng/mL)	0.43* (0.41*)	NS	NS
BMD lumbar spine (g/cm²)			
IGF-1 (μg/L)	0.56** (0.49*)	NS	0.39* (NS)
IGFBP-3 (mg/L)	0.44* (NS)	NS	NS
IGF-1/IGFBP-3 molar ratio	0.44* (NS)	NS	0.44* (NS)
Estradiol (pmol/L)	0.45* (0.53*)	NS	NS
Visfatin (ng/mL)	NS	NS	NS
Adiponectin (μg/mL)	NS	−0.60** (NS)	NS
Leptin (ng/mL)	0.52** (0.49*)	NS	NS

Note: W–L – weight-loaded sport; W–S – weight-supported sport; BMD – bone mineral density; IGF-1 – insulin-like growth factor-1; IGFBP-3 – IGF-binding protein-3. NS – not significant; Statistically significant, *p<0.05; Statistically significant, **p<0.01.

Stepwise multiple regression analysis indicated that IGF-1 and estradiol together explained 42.6% (R^2x100) of the total variance at FN BMD, and IGF-1 alone 35.4% (R^2x100) of the total variance at FN BMC in weight-loaded sport athlete group (data not shown).

DISCUSSION

The results of this study indicate that regular training in high-impact weight-bearing sport, such as rhythmic gymnastics, may positively contribute to the bone health of adolescent girls. In this group of athletes, the correlations of FN and LS BMD with IGF-1, estradiol and leptin, as well as FN BMD with IGF-1/IGFBP-3 molar ratio, and FN BMC with IGF-1, IGF-1/IGFBP-3 molar ratio and leptin remained significant even after adjusting for major confounders. Stepwise multiple regression analysis emphasised the association between IGF-1, estradiol and FN BMD as well as IGF-1 and FN BMC in this particular group. Similarly, Snow et al. [25] reported IGF-1/IGFBP-3 molar ratio to be the most robust predictor of FN BMD and suggested that IGF-1 may be a mediator of the muscle-bone relationship in young women with different exercise patterns.

Estradiol plays a significant role in bone formation. In pubertal females, estradiol inhibits bone resorption during growth and acts at higher concentrations to promote bone formation after menarche is reached [26]. Yilmaz et al. [28] found positive correlations between the levels of serum estradiol and BMD (LS and total body) in healthy non-athletic girls aged 10–15 years. It was observed that the increase in levels of serum estradiol at different pubertal stages in girls is accompanied by an increment in BMD values [28]. Our results suggest that regular weight-bearing physical activity during pubertal growth may positively affect bone mineralization, since estradiol and bone mineral values are interrelated significantly and independently from such major confounders as age, body height and body mass in the weight-loaded sport athlete group.

In female adolescents, Huang et al. [10] found that levels of adiponectin were negatively associated with total body BMD. The same authors reported positive associations between leptin and total body BMD [10]. Similar trends were observed in this study: FN and LS BMD were correlated inversely to adiponectin levels in the weight-supported sport athlete group; while FN and LS BMD had a positive relationship to leptin concentration levels in the weight-loaded sport athlete group. Evidence of the effects of visfatin on bone is scant: visfatin has been found to increase bone mineralization, promote glucose uptake, and downregulate osteocalcin secretion in human osteoblasts [27]. To date, only a few studies aimed to investigate the relationships of visfatin and bone mineral values in humans. Peng et al. [21] found visfatin to be related with hip BMD but not with LS or total body BMD in a population of Chinese men aged 20–80. In contrary, visfatin was not found to be an independent predictor of BMD in a population of post-menopausal Chinese women [30]. Recent investigation of the relationships of visfatin with bone density in middle-aged patients with metabolic syndrome revealed plasma visfatin levels to be positively correlated to LS BMD in men, but not women [11]. Although the above mentioned studies involved older populations, to our knowledge the relationships of visfatin with bone mineral values were not studied in pediatrics to date. In our study, no significant correlations were observed between visfatin levels and bone mineral variables in adolescent girls with different training patterns. It may be suggested that visfatin, known to be associated with adiposity and contributing to the relationship between fat mass and bone mineral values, may not play a significant role in bone tissue development in relatively lean healthy adolescent females. In this study, in weight-loaded sport athlete group a trend for lower levels of estradiol and leptin concentration was observed and FN BMD was significantly higher than that of the weight-supported sport athlete and non-athlete groups. This is in consistence to the findings of other studies. Munoz et al. [19] found leptin concentrations to be lower and FN BMD higher in adolescent rhythmic gymnasts when compared to controls. Courteix et al. [5] reported leptin concentrations of rhythmic gymnast to be as low as those observed in anorectic subjects; nevertheless, the BMD and BMC values in gymnasts were greater than in controls, concluding that physical activity counterbalanced the negative effect that low fat mass and leptin deficiency has on bone. It seems that hypoestrogenism and hypoleptinemia may be partly compensated by engaging in frequent high-impact loading [5, 19]. There was no surprise to find FN BMD to be significantly greater in weight-loaded sport athlete group in this study. It has been shown previously that gymnastics training is beneficial to bone health in children and adolescents [4, 20]. In a cross-sectional study of prepubescent girls, Scerpella et al. [24] observed a dose-depended relationship between BMD and hours per week of gymnastics activity. Swimming as a non-weight-bearing sport is considered to be associated with lower BMD in athletes [3]. The difference between the groups with regard to the BMD at the spine was not as pronounced as at proximal femur most likely because FN BMD experiences greater mechanical loading during high-impact activities than LS BMD.

There are several shortcomings to this study. The cross-sectional design does not allow us to derive a cause-effect conclusion in this study and the sample size is relatively small. The use of DXA technology provides a static measure of bone density. In this study, bone biochemical markers were not used, but could have provided insights into more acute independent measures of bone status in relation to hormone markers. Our results provide some background information on evaluation of the relationship of IGF-1, estradiol and different adipocytokines with bone mineral variables in adolescent female athletes and untrained controls.

In summary, after adjustment for major confounders, FN and LS BMD correlated with concentrations of IGF-1, estradiol and leptin, as well as FN BMD with IGF-1/IGFBP-3 molar ratio, and FN BMC with IGF-1, IGF-1/IGFBP-3 molar ratio, and leptin in adolescent female athletes of weight-loaded sport only. The concentrations of visfatin, a fairly new adipocytokine, were not related to bone parameters in healthy adolescent girls with different training patterns. The FN BMD was significantly higher in weight-loaded athletes, supporting the benefits of regular weight-bearing physical activity during growth and maturation.

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PRELIMINARY EVIDENCE FOR RELATIONS BETWEEN MOTIVATION AND BELIEFS RELATED TO EXERCISE DEPENDENCE

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ABSTRACT

Individuals engage in physical activity for a variety of reasons which are described by motivational determinants of behaviour. However, very little is known about the motivational antecedents of excessive exercise and exercise dependence. This study aimed to investigate the relationships between various motivating factors and specific beliefs characteristic for exercise dependence. Data were collected from a cross-sectional survey in a sample of volunteer recreational athletes (31 males aged 19–23 years and 54 females aged 18–34 years). Participants completed three questionnaires: Estonian 2 × 2 Achievement Goals in Sport Questionnaire was used to measure tendency to emphasize mastery and performance goals; Modified Estonian Exercise Motivation Questionnaire-2 to measure specific exercise motives; and an original Exercise Belief Scale was designed to estimate behavioural and control beliefs characteristic for exercise dependence. Results indicated that motivational orientation was a significant predictor of beliefs related to exercise dependence. Specifically, multiple regression analysis showed that perceived importance of exercise was significantly predicted by mastery approach and performance approach goals. Withdrawal effects, a hallmark for exercise dependence, could be predicted by mastery approach goals and competitive motive. Low control beliefs indicative for exercise tolerance appeared to be related with performance approach goals and competition motive. However, mastery approach also significantly predicted intentional avoidance of overtraining. Results suggest that beliefs related to exercise dependence are strongly related to various motivational aspects. Further investigation is needed to develop psychological assessment instruments to differentiate between normal and healthy exercise motivation and markers of overtraining and exercise dependence potential.

Keywords: *exercise beliefs, achievement goals, exercise motivation, recreational athletes*

INTRODUCTION

Over the past few decades, there has been an increasing interest in the role of exercise in promoting health and wellbeing. The health benefits of exercise and regular physical activity are well described [31, 33, 39, 41]. Specifically, exercise is characterized by planned, structured and repetitive bodily movement done to improve or maintain physical fitness [8]. This definition emphasizes favourable physical and biological changes that happen as a result of intentional movements. However, previous research also demonstrates that excessive exercise may yield harmful consequences for both physical and mental health [16, 26, 32, 42]. Although the concept of exercise addiction had a rather positive connotation in earlier literature [17], exercise dependence has been defined as a pathological condition [1, 29]. Clinical exercise dependence includes three or more of the following symptoms within a 12-month period: (a) tolerance (need of increasing exercise dosages for the same desired effect); (b) withdrawal (psychophysiological disturbance when deprived of exercise); (c) intention effects (engage in more exercise than intended); (d) perceived loss of control (unable to minimize or control exercise behaviour); (e) time (relatively big amount of time devoted to exercise-related activities); (f) conflict (exercise takes precedent over other aspects of life such as social, occupational, or recreational); and (g) continuance (continued exercise despite exercise-related physical or psychological problems) [2, 23]. This condition may occur as primary exercise dependence, where the physical activity is an end in itself, or as secondary exercise dependence manifested as a symptom of an eating disorder [40]. It has been estimated that exercise dependence may affect from 2 to 3% up to even 30% of the exercising population [4, 34, 36, 37].

The underlying mechanisms of exercise dependence reveal both psychological and biological antecedents of this pathological condition [19, 20]. In this study potential motivational precursors are investigated. Specifically, the aim of this study is to investigate relations between general motivational variables and more specific behavioural beliefs related to physical activity and excessive exercising.

Engagement in physical activity is widely described in the framework on the theory of planned behaviour (TPB; [10]). The TPB suggests that the motivation for physical activity is based on behavioural, normative, and control beliefs associated with physical activity [3]. Behavioural beliefs reflect individual's ideas about consequences of particular behaviour (e.g. physical activity helps me to control my body weight). Normative beliefs consist of individual's perceptions about the judgment of significant others (e.g. my family would approve my physical activity). Control beliefs indicate individual's beliefs about facilitating or inhibiting conditions (e.g. I could not find enough time to exercise). These types of beliefs comprise individual's attitudes toward physical activity, subjective norms about physical activity, and perceived control of engaging in physical activity, which, in turn, affect the initiation of physical activity via behavioural intention.

Based on previous research, a questionnaire was developed for assessment of explicit behavioural beliefs related to excessive exercise, exercise dependence, and overtraining risks for this study. Although behavioural beliefs related to exercise dependence are quite well documented [5, 18, 22, 30, 34] not much is known about more general motivational basis of exercise dependence. Research in competitive endurance athletes has shown that exercise dependence can be predicted by introjected regulation and identified regulation, but not by external regulation or intrinsic motivation [20]. Thus, internal rewards such as pride or shame, and perceived importance of physical activity might trigger excessive and obsessive exercising. Motivational variables have also been found to be related to burnout in elite athletes [27]. In this study hierarchical model of achievement motivation was applied for assessment of motivational characteristics [13, 14]. Achievement goals reflect desired competence-based aims that individuals target in evaluative settings. Originally, two distinctive achievement goals were identified based on the definition of personal competence: mastery and performance goals [11, 12]. Specifically, mastery goals reflect perceived competence in terms of absolute evaluative standards while performance goals reflect competence perception relative to the performance of others. Mastery oriented goals rely on comparisons with requirements of the task and intrapersonal comparisons with one's past attainment or potential attainment. Differently, individuals oriented towards performance goals define their competence in terms of interpersonal comparisons. In general, developing mastery goals is regarded as more adaptive than performance goals. Specifically, mastery orientation is related to selection of challenging tasks, effective study strategies, positive attitudes toward learning, and positive affect, whereas performance goals are associated with selection of easier tasks, trivial learning strategies, concern for social status, and thoughts of escape and behavioural withdrawal when difficulties arise [6, 7, 12, 21, 25]. However, if high perceived competence is combined with performance goals, then they are expected to support positive achievement outcomes [15, 35, 43]. In addition to more general achievement goals, intensity of specific exercise motives was related to behavioural beliefs related to excessive exercise and exercise dependence.

Accordingly, the aim of the present study was to assess relationships between features of general motivational orientation and specific exercise motives, and explicit beliefs related to excessive exercise and exercise dependence.

MATERIALS AND METHODS

Instruments

To measure characteristics of motivational orientation, individual exercise motives and beliefs related to exercise, three questionnaires were used:

1. *Estonian 2 x 2 Achievement Goals in Sport Questionnaire* (Est-AGQ-S [38]; original [9]). Est-AGQ-S is a sport-specific questionnaire designed to assess 4 distinctive dimensions for achievement goal motivation: mastery approach (e.g. *It is important to me to perform as well as I possibly can*), mastery avoidance (e.g. *I worry that I may not perform as well as I possibly can*), performance approach (*It is important for me to perform better than others*), and performance avoidance (*I just want to avoid performing worse than others*). The response format extended from 1 (*not at all like me*) to 7 (*completely like me*).
2. *Modified Estonian Exercise Motivation Questionnaire-2*, (EMQ-2EM [28]; original [24]). EMQ-2EM is a questionnaire developed for assessment of exercise motivation. Subscale scores were computed for 7 different exercise motives: Competition (e.g. *I exercise to compare my abilities with other peoples'*), Health (*I exercise because I want to maintain good health*), Appearance (*I exercise to improve my appearance*), Social Recognition (*I exercise to have fun being active with other people*), Fun and Relaxation (*I exercise because I find exercising satisfying in and of itself*), Physical Fitness (*I exercise to build up my strength*), and Flexibility (*I exercise to stay/become flexible*). The response format was to indicate how much each statement is true for the participant from *not at all true for me* (0) to *very true for me* (5).
3. *Exercise Belief Scale* (EBS) was developed for this study. Firstly, literature was reviewed to identify surveys that assess psychological risks for excessive exercise and exercise dependence. Secondly, interviews were conducted to explore recreational athletes' and coaches' perceptions of psychological foundations of excessive exercise. Individual interviews were conducted with recreational athletes and a focus group interview with 4 coaches from endurance sports, who had at least three years working experience with athletes. Based on information gathered from those interviews, a 23-item list was developed describing behavioural beliefs about consequences of exercise, control beliefs related to withdrawal and tolerance effects characteristic

for exercise dependence, and self-reported prevention of overtraining. In a pilot study, 222 recreational athletes and undergraduate students of sport sciences completed this working version of the questionnaire. A principal components method of factor extraction with orthogonal rotation was performed on the 23 items. To determine the number of factors to extract, scree plots and eigenvalues were examined. Using the eigenvalue of one criterion, seven factors were extracted (eigenvalues of 5.21, 2.69, 1.84, 1.61, 1.50, 1.35, and 1.06), accounting for 66.4% of the variance of EBS. Analysis of five, six and seven potential factors indicated that the seven-factor solution was a more interpretable factorial configuration. This solution clearly identified seven domains of Perceived Importance, Mood Regulation, Withdrawal Effects, Tolerance, Behaviour Compensation, Stress Avoidance, and Overtraining Prevention, with factor loadings above .50. Only two items loaded less than .50 on any factor and were discarded from further analysis. The factor structure is presented in Table 1. The total variance accounted for by the seven factors (21 items) was 68.0%.

Table 1. Factor structure of the Exercise Belief Scale

	F1	F2	F3	F4	F5	F6	F7
When I miss a scheduled exercise session I feel nervous or depressed	**0.82**	0.00	0.21	0.20	0.05	0.01	–0.09
When I have to skip an exercise session I feel guilty	**0.80**	–0.09	0.03	–0.04	0.13	–0.04	0.22
I might feel somehow guilty if I have to cancel a planned exercise session	**0.80**	0.08	0.13	0.14	–0.14	0.08	0.02
When I have to miss a scheduled workout I feel moody and irritable	**0.56**	0.23	0.28	0.35	–0.04	0.28	0.21
I try not to train too much as it could be deleterious	0.09	**0.88**	–0.02	–0.03	0.01	–0.11	0.03
I restrict my training load to prevent overtraining	0.07	**0.88**	–0.05	0.01	–0.07	0.02	0.23
I regulate my training load to prevent injuries	–0.17	**0.76**	0.11	0.19	0.08	–0.05	–0.18
I have to increase the duration of my exercise sessions constantly to get the desired benefits	0.11	–0.06	**0.74**	0.05	0.22	0.13	0.05
I just feel that I cannot decrease intensity of my exercise sessions	0.36	–0.04	**0.74**	–0.02	–0.07	–0.01	0.17

	F1	F2	F3	F4	F5	F6	F7
I just cannot limit the frequency of my exercise sessions	0.17	–0.03	**0.59**	0.23	–0.07	0.24	0.29
I continually increase the intensity of my exercise sessions to get the effects that I want	0.13	0.09	**0.58**	–0.11	0.13	–0.28	0.27
My exercising helps me to change my mood (feel "high". escape from everyday life etc.)	0.23	0.06	0.03	**0.77**	–0.06	0.06	0.31
My exercising improves my mood	0.10	0.01	0.01	**0.84**	0.10	–0.09	0.02
When I have been eating too much. I try to balance it out by increased my training load	0.00	0.00	0.06	–0.04	**0.73**	0.10	–0.21
My exercising helps me to stick to a healthy diet	–0.20	0.10	0.18	0.22	**0.67**	0.04	0.17
I feel proud when I exercise even more than I planned to	0.29	–0.23	–0.13	–0.06	**0.62**	–0.23	0.18
My workouts give me an opportunity to withdraw from other people	0.06	–0.13	–0.07	–0.04	–0.09	**0.82**	0.08
To be honest. I exercise so that I can get out of spending time with my family/friends	–0.01	0.11	0.32	–0.34	0.23	**0.60**	0.09
I exercise to avoid feeling tense	0.22	–0.33	0.16	0.32	0.27	**0.50**	–0.21
My exercising is the most important thing in my life	0.10	0.03	0.41	0.18	–0.08	0.23	**0.68**
My exercising provides me physical challenges	0.06	0.31	0.18	0.31	0.15	–0.22	**0.59**
I feel nervous when I have to have a break in my exercise sessions	0.42	0.24	0.18	0.09	0.40	0.13	0.46
My exercising helps me to meet new people	0.03	0.19	0.50	0.50	0.07	–0.14	–0.08

Note: F1 – Withdrawal Effects, F2 – Overtraining Prevention, F3 – Tolerance, F4 – Mood Regulation, F5 – Behavioural Compensation, F6 – Stress Avoidance, F7 – Perceived Importance. Factor loadings above 0.50 are marked in boldface

Participants and procedure

Data were collected from cross-sectional survey in 2 exercise clubs and from undergraduate and master students of sport and exercise science. Inclusion criterion for volunteers was regular recreational exercising and participation in amateur competitions. The author of this study distributed the questionnaires personally to each participant and explained the general purpose of the study. Participants returned the completed questionnaires within 2 weeks. Out of 122 delivered questionnaires 85 (69.6%) were returned. Therefore, data from 54 female recreational athletes (aged between 18 and 34 years, mean age 20.8±2.8 years) and 31 males (aged between 19 and 31 years, mean age 21.6±3.5 years) were included in the study.

Statistical analysis

The data were analysed using the Statistical Package for the Social Sciences (IBM SPSS Statistics 20; IBM Corp). Reliability analyses were carried out using Cronbach's alpha. Most variables demonstrated acceptable levels of internal consistency. The Pearson product-moment correlation was used to determine associations between all motivational variables. A stepwise regression analysis was conducted to evaluate the relationship between the achievement goals, exercise motives, and exercise beliefs. An alpha level of 0.05 was used for all statistical tests.

RESULTS

The descriptive values for all questionnaires are presented in Table 2.

Correlations among measured variables are presented in Table 3. As this pattern of significant relations between motivational variables and exercise beliefs was rather complex, stepwise multiple regression analysis was performed in order to estimate multiple correlations (Table 4). This method is useful for a longer list of independent variables, some of which may be useful predictors, but some of which can be redundant. In such cases stepwise multiple regression searches for best subsets of predictors.

Perceived importance of exercise was significantly predicted by both mastery and performance approach goals. However, independently from those two, competition motive was also a strong predictor of perceived importance of exercise.

For mood regulation, three prediction models were generated. Both performance and mastery approach, together with fun and relaxation motive predicted the belief that exercise is useful for mood regulation, only the last one being significant individual predictor. Next, mastery avoidance goal had a negative predictive effect on mood regulation, together with high fun and relaxation motive. The best predictive model for mood regulation beliefs involved higher fun and relaxation and social relatedness motives with lower mastery avoidance goals.

Table 2. Summary descriptive statistics and internal reliability for all variables (n=85)

Variable	Mean±SD	Range	Cronbach α
Est-AGQ-S			
Mastery Approach	5.67±1.06	1.00–7.00	0.75
Mastery Avoidance	4.63±1.28	1.00–7.00	0.79
Performance Approach	4.64±1.47	1.00–7.00	0.84
Performance Avoidance	4.27±1.57	1.00–7.00	0.88
EMQ-2EM			
Appearance	16.56±8.33	0.00–30.00	0.92
Competition	26.28±11.59	0.00–45.00	0.93
Health	20.76±6.44	0.00–32.00	0.90
Social Relatedness	8.98±4.57	0.00–15.00	0.96
Fun & Relaxation	22.18±5.12	8.00–30.00	0.78
Physical Fitness	20.15±4.94	0.00–25.00	0.81
Flexibility	5.72±2.87	0.00–10.00	0.92
EBS			
Perceived Importance	3.65±0.83	1.50–5.00	0.57
Mood Regulation	4.45±0.62	2.00–5.00	0.78
Withdrawal Effects	3.24±0.91	1.00–5.00	0.83
Tolerance	2.62±0.75	1.25–4.25	0.73
Behavioural Compensation	3.17±0.79	1.00–5.00	0.51
Stress Avoidance	2.19±0.67	1.00–3.67	0.53
Overtraining Prevention	3.16±0.98	1.00–5.00	0.85

EST-AGQ-S – Estonian 2 × 2 Achievement Goals in Sport Questionnaire, EMQ-2EM – Modified Estonian Exercise Motivation Questionnaire-2, EBS – Exercise Belief Scale

Table 3. Summary of correlational analysis between all variables

EBS	Perceived Importance	Mood Regulation	Withdrawal Effects	Tolerance	Behaviour Compensation	Stress Avoidance	Overtraining Prevention
Est-AGQ-S							
Mastery Approach	**0.43**	0.07	**0.31**	**0.32**	–0.04	0.00	**0.29**
Mastery Avoidance	0.09	–0.15	0.16	0.12	0.16	0.04	0.08
Performance Approach	**0.41**	0.09	**0.24**	**0.38**	0.20	–0.07	0.09
Performance Avoidance	0.10	0.16	**0.26**	**0.27**	**0.23**	0.14	0.09
EMQ-2EM							
Appearance	–0.05	0.02	–0.13	–0.08	**0.61**	0.10	0.04
Competition	**0.71**	**0.37**	**0.39**	**0.48**	.00	0.09	**0.27**
Health	0.14	0.17	0.14	0.05	0.18	0.16	0.19
Social Relatedness	**0.27**	**0.38**	0.21	**0.32**	–0.08	0.02	**0.26**
Fun & Relaxation	**0.32**	**0.60**	**0.27**	0.20	0.15	**0.46**	0.10
Physical Fitness	**0.44**	0.19	**0.35**	**0.28**	0.11	0.06	**0.36**
Flexibility	007	0.16	0.10	–0.02	0.03	–0.11	0.17

Note: $N = 85$ (casewise deletion of missing data). $P < .05$ is marked in boldface.

Table 4. Stepwise regression analysis of exercise beliefs as a function of achievement goals and exercise motives

Dependent Variable	Predictor	Model 1			Model 2			Model 3		
		B	SE B	β	B	SE B	β	B	SE B	β
Perceived importance	Performance Approach	0.150	0.063	**0.263**	0.003	0.054	–0.006			
	Mastery Approach	0.245	0.086	**0.313***	0.072	0.073	0.092			
	Competition				0.429	0.063	**0.681****			
	Adjusted R^2		0.224			0.513				
	F		**12.825****			**29.750****				
Mood Regulation	Performance Approach	0.015	0.042	0.036	0.058	0.043	0.141	0.051	0.042	0.121
	Mastery Approach	0.023	0.056	–0.003	0.023	0.057	0.040	0.002	0.054	–0.004
	Fun & Relaxation	0.421	0.063	**0.603****	0.423	0.060	**0.605****	0.364	0.062	**0.521****
	Mastery Avoidance				0.125	0.046	**–0.265***	0.132	0.045	**–0.280***
	Social Relatedness							0.098	0.036	**0.248***
	Adjusted R^2		0.345			0.392			0.438	
	F		**15.387****			**14.244****			**13.776****	
Withdrawal effects	Mastery Approach	0.263	0.091	**0.307***	0.129	0.102	0.150			
	Competition				0.217	0.083	**0.309**	0.271	0.072	**0.385****
	Adjusted R^2		0.083			0.144			0.138	
	F		**8.416***			**7.913***			**14.118****	
Tolerance	Performance Approach	0.195	0.053	**0.377****	0.086	0.060	0.167			
	Competition				0.225	0.068	**0.385***	0.278	0.057	**0.476****
	Adjusted R^2		0.131			.227			0.217	
	F		**13.414****			**13.074****			**23.744****	

Dependent Variable	Predictor	Model 1			Model 2			Model 3		
		B	SE B	β	B	SE B	β	B	SE B	β
Behavioural Compensation	Performance Approach	0.151	0.066	**0.227**	0.108	0.059	0.198	0.097	0.047	**0.178**
	Mastery Approach	0.127	0.092	–0.170						
	Appearance							0.344	0.050	**0.601****
	Adjusted R^2		0.039			0.027			0.385	
	F		2.647			3.317			**26.630****	
Stress Avoidance	Fun & Relaxation	0.365	0.078	**0.462****	0.394	0.078	**0.499****			
	Flexibility				–0.095	0.047	**–0.200**			
	Adjusted R^2		0.204			0.234				
	F		**21.99****			**13.495****				
Avoiding Overtraining	Mastery Approach	0.273	0.099	**0.293***	0.145	0.109	0.156			
	Physical Fitness				0.291	0.116	**0.292**	0.364	0.103	**0.365***
	Adjusted R^2		.074			0.131			0.122	
	F		**7.580***			**7.166***			**12.430***	

Note: Statistically significant parameters are printed in bold $p < .05$, * $p < .01$, ** $p < .001$

Interestingly, the best independent predictor of behavioural beliefs related to withdrawal effects and tolerance was the competition motive. Stress avoidance beliefs were best predicted by fun and relaxation motive.

A clear result emerged among potential predictors of behavioural beliefs related to compensatory effects of exercising. The strongest predictor of behavioural compensation beliefs was appearance motive, accounting for 38.5% of the total variance together with performance approach goals.

Finally, beliefs related to deliberate avoidance of overtraining were independently predicted either by mastery approach goals or motives related to physical fitness.

DISCUSSION

In this study I examined correlation and regression between the motivational variables, and explicit behavioural beliefs and control beliefs related to excessive exercise and exercise dependence. Overall, the results demonstrated that achievement goal orientation and exercise motives could predict specific beliefs that are known as characteristic for exercise dependence.

The most unspecific predictors of exercise beliefs appear to be mastery approach goals. Specifically, mastery approach goals are independent predictors of both withdrawal effects and deliberate avoidance of overtraining. Together with performance approach goals mastery approach goals account for perceived importance of exercise which reflects personal value placed on one's exercising. Thus, both personal and interpersonal goals with positive valence increase the personal worth of exercise. However, it is important to keep the overall balance of different aspects of life in mind. Recently, Kim et al. [26] have demonstrated an inverted-U relationship between physical activity and mental health. In their study of general population they have shown that the optimal amount of exercise is between 2.5 and 7.5 hours per week. Although they did not establish causal relationships, the most plausible explanation is that crossing of this limit may cause imbalance between different aspects of life such as social relationships, family life, and academic/occupational functioning. In addition, mastery approach goals have also a weak predictive value for behavioural beliefs about the potential of exercise in mood regulation.

Further, when predicting overtraining avoidance, specific fitness motive is of big value. Thus, independently from motivational orientation, individuals with improved fitness in mind most likely take care of reasonable balance between training and recovery. Differently, beliefs about potential compensatory effects of exercising are best predicted by appearance motive, together with performance approach goals. Thus, people who exercise in order to achieve/maintain aesthetic physical appearance might hope to even out their excessive eating by excessive exercising. Alternatively, this relationship may also reflect behavioural beliefs about excessive exercising as a feature of disturbed eating behaviour.

Another clear relationship emerged between the fun and relaxation motive and behavioural beliefs about potential stress avoidance due to exercising. This motive independently explains stress avoidance beliefs by 20%. However, it is important to note that in this study stress avoidance was operationalized as avoidance of stressful situations (avoiding tension, but also avoiding social encounters). Thus, people with relaxation motives could also exhibit escaping from social relations.

Finally, the need for higher amounts of exercise load – indicative for exercise tolerance – can be explained independently by competition motivation and by performance approach goals. Thus, the warning sign of exercise dependence, manifested in beliefs of low control over training load and intensity occurs in individuals with interpersonal comparison in mind. Appropriate training instructions for competitive exercisers might be of great relevance in prevention of exercise pathology.

Taken as a whole, this study further supports that specific beliefs about the benefits and consequences of exercising – but also about personal control over exercising are related to different achievement goals and exercise motives [4, 20, 27]. While motivation in exercise participants is an important asset in achieving health benefits and personal accomplishment, high motivation may also be related to adopting maladaptive beliefs that could promote unhealthy patterns of exercise behaviour. However, this study has significant limitations. The EBS needs further development and validation. Specific items of the EBS need further refinement, as three of EBS subscales showed poor internal consistency. In addition, the criterion and predictive validity of EBS should be determined. Further research could evaluate if motivational profile of exercise participants could discriminate between pathological and healthy exercisers.

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GENDER DIFFERENCES IN HEALTH-RELATED QUALITY OF LIFE AMONG ESTONIAN ADOLESCENTS: A 6-MONTH FOLLOW-UP

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ABSTRACT

This study aimed to determine the differences between boys and girls in the health-related quality of life (HRQoL) and its domains of physical health, emotional-, social-, and school-related functioning over a six-month period. Six hundred and forty seven Estonian secondary school students participated in the study, of whom 401 (177 boys and 224 girls; age 13.60±0.63 years) filled in the HRQoL questionnaire (PedsQL™ 4.0 Generic Core Scales) on three occasions: baseline, 3-month, and 6-month follow-ups. To analyse the changes in HRQoL among boys and girls over a six-month period, repeated measures ANOVA was performed. The results revealed that boys scored significantly higher compared to girls on emotional functioning at all three time points over a six-month period. As for total score of HRQoL, and physical and psychosocial health, boys scored significantly higher than girls only on the first and second measurements. No significant changes in total score of HRQoL as well as its domains were followed in boys or girls between baseline, 3-month, and 6-month follow-ups. The lower perceptions of total score of HRQoL as well as its domains of physical health, emotional functioning, and psychosocial health among girls in Estonia over a six month period support the findings of previous longitudinal studies.

***Keywords**: adolescence, longitudinal study, physical health, psychosocial health, PedsQL™ 4.0 Generic Core Scales*

INTRODUCTION

The topics pertaining health-related quality of life (HRQoL) have received much attention in both clinical [10] and health-related surveys [5]. Studies carried out on healthy children are mainly necessary because the quality of life of children and adolescents is directly related to their quality of life in adulthood [3].

One of the most commonly used questionnaire assessing the HRQoL with its domains of physical, emotional, social and school-related functioning in children and youngsters is the PedsQL™ 4.0 Generic Core Scale [14], which includes both self-reports and parents' opinions of their children in the following age groups: 5–7, 8–12 and 13–18 years [15, 11]. The HRQoL in children aged 2–4 years is evaluated only on the basis of their parents' proxy-reports. Several studies have shown that the questionnaire is valid and reliable in measuring the HRQoL of schoolchildren as well as in population surveys [11, 12, 13, 16].

Cross-sectional studies have shown that HRQoL of girls in their early teenage years is significantly lower than that of boys, being mainly evident in the physical and psychological aspects (i.e., mood and emotions) of HRQoL [2, 3, 4, 16]. In addition, the few long-term studies carried out have revealed that the changes occurring in early teenage years have a negative impact on HRQoL and all of its domains, especially in girls [7, 8]. Palacio-Vieira et al. [8], for example, studied HRQoL of Spanish children and adolescents aged 11–21 years, and found that the especially drastic negative changes occurred in the groups of girls aged 13–17 within a three-year study period. To date, there is no evidence of studies that have longitudinally observed the perceptions of HRQoL in the most sensitive age group (i.e. adolescents aged 13–14) in Eastern European countries, such as Estonia.

The main aim of the study was to establish gender differences in the total score of HRQoL and its domains of physical, psychological, social, and school-related functioning among Estonian adolescents over a six-month period. The hypothesis of the study was that the perceptions of physical and psychological health aspects of HRQoL will be significantly higher among boys than those of girls over a six-month period.

MATERIALS AND METHODS

Participants and procedures

Secondary school students (n=647) from a town of 100,000 inhabitants located in southeast of Estonia took part in the first data collection. The first data collection was carried out one month after the beginning of school year (Time 1 – October 2009). The second data collection was administered three months later (Time 2 – January 2010) and the third data collection was carried out when the school year was drawing to a close (Time 3 – April 2010). In total, 576 students took part in the second and 497 students in the third data collection. The 401 students (177 boys and 224 girls; age 13.60±0.63 years) completed the questionnaire at all three time points. Students' dates of birth and gender were used as matching indices. The independent samples t-tests were conducted on the mean scores of each study variable to test for possible differences between students who completed the questionnaire at all three time points and those who dropped out. No significant differences emerged on the study variables, except on emotional functioning revealed that students who dropped out (73.88±20.16) from the study exhibited significantly (t=2.13, $p<0.05$) higher score compared to students who completed the questionnaire at all three time points (70.37±15.44). This suggests that cautious should be exercised when interpreting results concerning the emotional functioning domain of HRQoL.

Prior to data collection, permission to carry out the study was obtained from the head teachers of all schools. The informed consent was obtained from the participants and their parents via a letter sent home with each child. Parents' permission was considered approved if they did not send the letter back to the school. No letters with refusal were returned.

Measures

HRQoL: The PedsQL™ 4.0 Generic Core Scales [14], adapted into Estonian by Viira and Koka [16], was used to assess participants' perceptions of HRQoL with domains of physical health (8 items, e.g., "It is hard for me to walk more than one block"), emotional functioning (5 items, e.g., "I worry about what will happen to me"), social functioning (5 items, e.g., "Other kids tease me"), school-related functioning (3 items, e.g., "I have trouble keeping up with my schoolwork"), days missed from school due to illness (2 items, e.g., "I miss school to go to the doctor or hospital"), and psychosocial health that includes social, emotional and school functioning subscales. Participants were asked to indicate how much of a problem has this been during the past one month on a 5-point scale ranging from 0 (never a problem) to 4 (almost always a problem). Prior to data analysis items were reversed-scored and linearly transformed to a 0 to 100 scale (i.e., 0=100, 1=75, 2=50, 3=25, and 4=0). In the present study, the Cronbach's alphas for total score of HRQoL and its dimensions of physical health, psychosocial health, emotional functioning, social functioning, school-related functioning, days missed from school due to illness at time 1 were 0.87, 0.77, 0.84, 0.78, 0.80, 0.68, and 0.40, respectively; at time 2 were 0.89, 0.82, 0.86, 0.79, 0.82, 0.70, and 0.59, respectively; and at time 3 were 0.92, 0.86, 0.90, 0.83, 0.87, 0.77, and 0.65, respectively.

Statistical analysis

Data were analysed using SPSS 17.0 for Windows. Two-way analysis of variance (ANOVA) for repeated measures with time (baseline, 3-month, and 6-month follow-ups) as within subject factor and gender (boys, girls) as between subject factor was used to analyse the changes in the total score of HRQoL as well as its domains of physical health, psychosocial health, social functioning, emotional functioning, school-related functioning, and days missed from school due to illness. Significant main effects of time were further analysed using paired samples t-tests with Bonferroni correction. Since three paired samples t-tests were performed, the conventional significance level of 0.05 was set at $p<0.017$ in order to prevent Type I error. Significant main effects of gender were further analysed using independent samples t-tests at each time points.

RESULTS

Gender differences in total score of HRQoL over a 6-month follow-up

Results of the ANOVA for repeated measures indicated that there was a significant main effect of time ($F_{1,87,\ 747,13}=4.58$, $p<0.01$, $\eta_p^2=0.01$) and gender ($F_{1,\ 399}=11.53$, $p<0.001$; $\eta_p^2=0.03$), but not significant interaction between time and gender ($F_{1,87,\ 747,13}=1.73$, $p>0.05$, $\eta_p^2=0.004$). For both boys and girls, after the Bonferroni correction, paired samples t-tests did not revealed statistically significant changes between baseline, 3-month, and 6-month follow-ups. Independent samples t-tests indicated that boys scored significantly higher than girls in total score of HRQoL at time 1 (boys 75.43±12.18 vs. girls 70.30±12.45, $t=4.14$, $p<0.001$) and time 2 (boys 75.13±12.89 vs. girls 71.46±12.81, $t=2.84$, $p<0.01$), but not at time 3 (boys 72.92±16.30 vs. girls 70.07±13.79, $t=1.89$, $p>0.05$) (Figure 1A).

Gender differences in physical health domain of HRQoL over a 6-month follow-up

Results of the ANOVA for repeated measures revealed significant main effect of time ($F_{1,90,\ 759,90}=5.23$, $p<0.01$, $\eta_p^2=0.01$) and gender ($F_{1,\ 399}=10.66$, $p<0.001$; $\eta_p^2=0.03$), but not significant interaction between time and gender ($F_{1,90,\ 759,90}=1.03$, $p>0.05$, $\eta_p^2=0.003$). Again, for both boys and girls paired samples t-tests did not revealed statistically significant changes between baseline, 3-month, and 6-month follow-ups. Independent samples t-tests indicated that boys scored significantly higher than girls in physical health at time 1 (boys 76.61±15.57 vs. girls 70.95±14.32, $t=3.78$, $p<0.001$) and time 2 (boys

76.04±16.69 vs. girls 71.88±15.13, t=2.61, p<0.01), but not at time 3 (boys 73.38±19.11 vs. girls 69.95±16.64, t=1.92, p>0.05) (Figure 1B).

Gender differences in psychosocial health domain of HRQoL over a 6-month follow-up

Results of the ANOVA for repeated measures revealed significant main effect of time ($F_{1,87, 744,66}$=4.02, p<0.01, η_p^2=0.01) and gender ($F_{1, 399}$=13.66, p<0.001; η_p^2=0.03), but not significant interaction between time and gender ($F_{1,87, 744,66}$=2.39, p>0.05, η_p^2=0.006). Paired samples t-tests, however, did not revealed statistically significant changes between baseline, 3-month, and 6-month follow-ups for both boys and girls. Independent samples t-tests indicated that boys scored significantly higher than girls in psychosocial health at time 1 (boys 77.46±13.15 vs. girls 71.45±13.30, t=4.52, p<0.001) and time 2 (boys 77.03±13.84 vs. girls 72.86±13.74, t=3.17, p<0.01), but not at time 3 (boys 74.55±17.05 vs. girls 71.49±14.89, t=1.92, p>0.05) (Figure 1C).

Gender differences in emotional functioning domain of HRQoL over a 6-month follow-up

Results of the ANOVA for repeated measures revealed significant main effect of gender ($F_{1, 399}$=33.64, p<0.001; η_p^2=0.09), but not of time ($F_{1,95, 778,66}$=0.55, p>0.05; η_p^2=0.001) nor significant interaction between time and gender ($F_{1,95, 778,66}$=2.22, p>0.05; η_p^2=0.006). Independent samples t-tests indicated that boys scored significantly higher than girls in emotional functioning at time 1 (boys 76.50±18.33 vs. girls 65.37±19.26, t=6.02, p<0.001), time 2 (boys 75.37±13.15 vs. girls 66.25±13.30, t=4.78, p<0.01), and time 3 (boys 73.59±21.28 vs. girls 66.25±19.66, t=3.58, p<0.01) (Figure 1D).

Gender differences in social functioning domain of HRQoL over a 6-month follow-up

Results of the ANOVA for repeated measures revealed that there was no significant main effect of time ($F_{1,91, 762,96}$=2.38, p>0.05; η_p^2=0.006), gender ($F_{1,399}$=0.02, p>0.05; η_p^2=0.0001), nor significant interaction between time and gender ($F_{1,91, 762,96}$ =1.38, p>0.05; η_p^2=0.003) (Figure 1E).

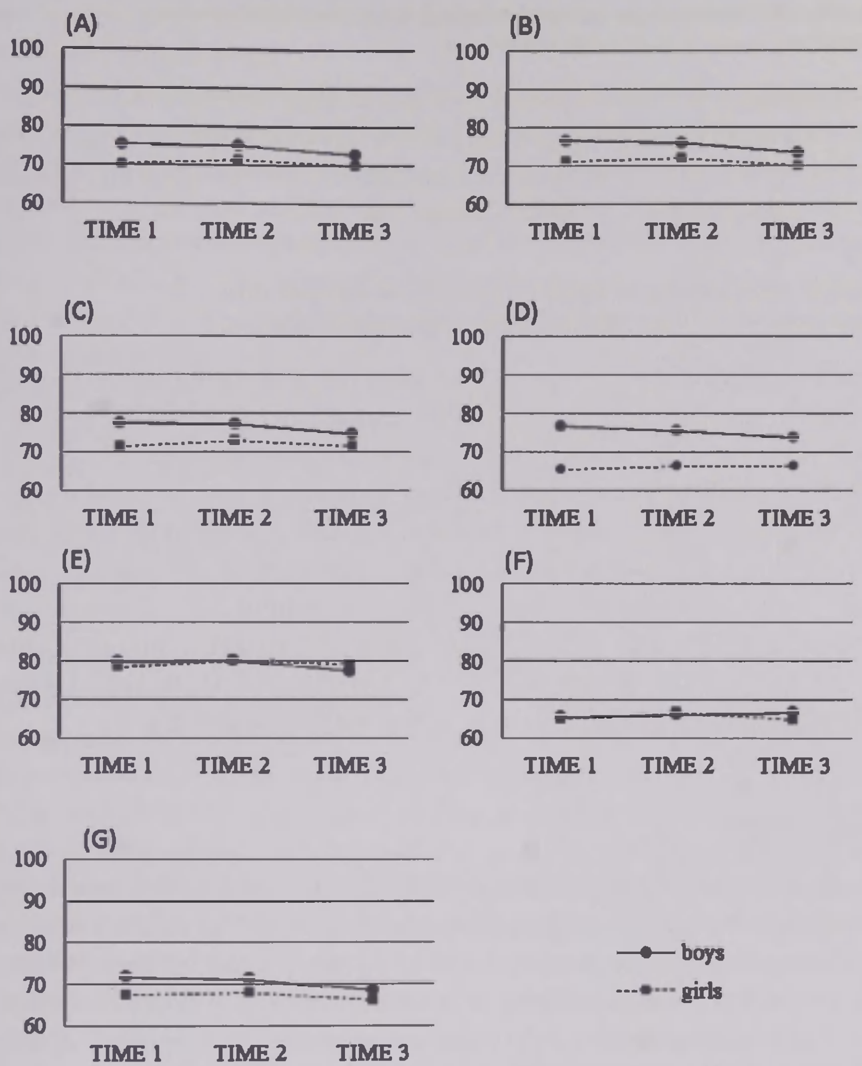

Figure 1. Gender differences in (A) total score of HRQoL and its domains of (B) physical health, (C) psychosocial health, (D) emotional functioning, (E) social functioning, (F) school-related cognitive functioning, and (G) days missed from school because of illness over a six month period. Note. The values between 0 and 60 have been omitted because all means were between 60 and 100

Gender differences in school-related functioning domain of HRQoL over a 6-month follow-up

Results of the ANOVA for repeated measures revealed that there was no significant main effect of time ($F_{2,798}$=1.05, p>0.05; η_p^2=0.003) gender ($F_{1,399}$=0.11, p>0.05; η_p^2=0.0001) nor significant interaction between time and gender ($F_{2,798}$=0.73, p>0.05; η_p^2=0.002) (Figure 1F).

Gender differences in days missed from school due to illness domain of HRQoL over a 6-month follow-up

Results of the ANOVA for repeated measures revealed significant main effect of time ($F_{2,798}$=3.32, p<0.05, η_p^2=0.008) and gender ($F_{1,399}$=4.80, p<0.05; η_p^2=0.01), but not significant interaction between time and gender ($F_{2,798}$=0.41, p>0.05, η_p^2=0.001). Paired samples t-tests, however, did not revealed statistically significant changes between baseline, 3-month, and 6-month follow-ups for both boys and girls. Independent samples t-tests indicated that boys scored significantly higher than girls in days missed from school due to illness at time 1 (boys 71.75±19.76 vs. girls 67.29±18.13, t=2.35, p<0.05), but not at time 2 (boys 71.19±20.29 vs. girls 67.69±19.42, t=1.75, p>0.05) and time 3 (boys 68.36±23.80 vs. girls 65.85±19.01, t=1.18, p>0.05) (Figure 1G).

DISCUSSION

The aim of the study was to analyse gender differences in HRQoL among Estonian adolescents aged 13–14 years over a period of six months. As there were no significant changes in the mean scores of both boys and girls between baseline and two follow-ups, the following discussion focuses on gender differences. Our results showed gender differences in the total score of HRQoL and its domains of physical health, psychosocial health, emotional functioning, and absence from school due to an illness.

It is especially remarkable that within the six-month period, the mean score of emotional functioning aspect of HRQoL were consistently and statistically significantly higher in boys than in girls. These results are consistent with previous cross-sectional [1, 3, 16] and longitudinal studies [2, 8]. According to several researchers [6, 9], the causes of significantly lower scores on emotional functioning aspect of HRQoL in girls lie in extensive hormonal changes in that age, resulting in increased levels of anxiety and thereby a significant drop in psychological quality of life. Furthermore, Kolip et al. [6] have stated that the way boys solve problems differs from girls. The latter authors have argued that upon emergence of problems girls become rather introverted whereas boys become extroverted, resulting in psychosomatic and mental deviances in early adolescence years.

As for the total score of HRQoL, physical health and psychosocial health, the mean scores of boys were significantly higher than those of girls on both the first and second measurement time, but not on the third time. Previous cross-sectional [1, 3, 16] and longitudinal [2, 8] studies have found similar results, i.e. the mean scores of boys tend to be considerably higher in the mentioned domains of HRQoL than those of girls. One of the most important reasons why girls perceive their HRQoL as relatively poor compared to boys lies in problems related to menstruation [2, 6]. However, it is still debatable why the perception of HRQoL in most of its domains becomes more negative in boys in the second (i.e., six-month) follow-up of the study, so that differences in the mean scores between boys and girls are no longer statistically significant. The six-month follow-up of the study fell near the end of the school year (i.e., April), when preparations for the final exams begin. It is fairly likely that exams at the end of the school year are more stressful for boys than for girls, which could also contribute to the poorer perception of their HRQoL.

Although this study provided a first overview of the perceptions of health-related quality of life in adolescents over a six-month period in a post-Soviet country, such as Estonia, the study also has its limitations. The first limitation lies in the relatively small sample, thus reducing the level of generalizability at the country level. The second limitation concerns the focus on only 13–14-year-old adolescents. It would also be necessary to study longitudinally pre-pubertal children as well as younger and older adolescents. The third limitation pertains to the two-item subscale of days missed from school due to illness from the PedsQL™ 4.0, in particular the low internal consistency of the items. Thus, there is a real need to rephrase these two items in order to be sure both items measuring the same content. For example, Viira and Koka [16] have stated that although both statements assess the reasons for absence from school, one statement ("I miss school to go to the doctor or hospital.") does not necessarily reflect absences from school due to illness, as going to see a doctor may also be related to regular health checks.

In conclusion, the results of the study revealed that female adolescents in Estonia scored lower in most of the domains of HRQoL than those of boys during a six-month follow-up, confirming the both previous cross-sectional and longitudinal studies.

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DISABILITY DISCOURSE, PHYSIOTHERAPY AND PHYSICAL ACTIVITY IN THE LIVES OF PEOPLE WITH TRAUMATIC SPINAL CORD INJURY

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ABSTRACT

The aim of this study was to explore the experiences with disability discourse, physiotherapy and physical activity (PA) of people with traumatic spinal cord injury (SCI). Eight men with traumatic SCI participated in the study. Semi-structured interviews were carried out with each participant. The participants emphasized the importance of peer counselling in coping with traumatic SCI but also identified several problems in their everyday lives: limited outside mobility during the winter months, limited accessibility, different disturbing societal attitudes and behaviours towards people using a wheelchair, and limited financial aid for people with disabilities. They had mostly positive experiences with physiotherapy and suggested that physiotherapists should focus on developing their general competencies and using an individual client-centred approach. The participants valued PA but were rather inactive due to function- and health-related, motivational and socio-environmental barriers. The combination of different barriers and facilitators to PA varied for each participant, thereby demonstrating the heterogeneity of their PA experiences. When looking at the described benefits of both physiotherapy and PA, the main forms of creating a strong sense of self-efficacy were represented.

***Keywords**: spinal cord injury, qualitative research, disability discourse, physical activity, physiotherapy*

INTRODUCTION

People with disabilities face many problems that prevent them from engaging fully in the society. These include accessibility, participation and non-discriminatory health-care, and the need for improvement in these areas is emphasized in different international documents [5, 16, 18]. The aim of this study was to explore the experiences of people with traumatic spinal cord injury (SCI) with disability discourse (e.g. accessibility and societal attitudes), physiotherapy and physical activity (PA).

Disability discourse encompasses attitudes towards disabilities and people with disabilities, medical knowledge, disability politics, media representation, social inclusion, accessibility, etc. Therefore, the dominant disability discourse in the society may have real (positive or negative) consequences for people with disabilities [18].

One health condition that may cause long-term disability and also have a profound impact on quality of life is traumatic SCI [14]. It is defined as neurological damage of the spinal cord following trauma which impairs motor, sensory and autonomic functions [8]. The incidence rate of traumatic SCI in Estonia from 1997 to 2007 was 39.7 per million population which is among the highest in Europe [14].

Physiotherapy aims to improve the health-related quality of life of people with SCI by improving their ability to participate in activities of daily life [8]. Because physiotherapy as a profession and an academic discipline aims at a holistic biopsychosocial approach, it should explore how people adapt to changing physical conditions that influence their capacity to move and act in their environment. In doing that, it should also include the experiences of people who are experts in living with a certain health condition [3].

What is more, both physiotherapy and PA aim to improve the participation level of people with SCI. However, people with physical disabilities, including people with SCI, are often physically inactive. This may restrict their functional independence and increase the risk for chronic diseases and secondary complications [10, 17]. Furthermore, PA may help to re-establish a positive identity after SCI. In order to promote and implement a physically active lifestyle among this population, it is vital to explore their thoughts about and experiences with PA [17].

MATERIALS AND METHODS

Study participants were found through the mailing list of the Estonian Union of Persons with Mobility Impairment, using snowball sampling method and with the collaboration of Haapsalu Neurological Rehabilitation Centre. Inclusion criteria were predefined as follows: wheelchair user after traumatic SCI for a minimum of 2 years, age 20–39. Semi-structured interviews were carried out with 8 participants from different parts of Estonia. They were all male, mean age 31 years, wheelchair users for an average of 7 years, 7 with cervical SCI and 1 with thoracic SCI. Interviews were carried out from May to November 2011, the questions were open-ended and non-leading. The duration of the interviews was 1–1.5 hours, they were tape-recorded, transcribed (using the unfocused transcription method [6]) and thematically analyzed, i.e., the recurrent themes were categorized, compared and contrasted [6]. In addition, member checking process [3] was carried out: the analysis was sent to the participants and 3 of them gave feedback to the study. Research Ethics Committee of the University of Tartu approved the study.

RESULTS

Disability discourse

Traumatic SCI brought about sudden changes in the participants' lives. They had mostly experienced negative feelings after the trauma and had to readjust to their "new" body, decreased independence and changes in previous plans and dreams. However, each participant had different experiences with life after SCI and also a distinct understanding of disability.

In order to cope and adapt to the new situation, the participants emphasized the importance of learning from other people with SCI and having the opportunity to share their experiences. Before the trauma they had little knowledge of people with (physical) disabilities but afterwards felt that they belonged to a new community (of people using a wheelchair) that could understand them better than the general public.

The participants also identified several problems in their everyday lives: limited outside mobility during the winter months, limited accessibility to the physical environment (including health care facilities, municipal buildings and sports facilities), different disturbing societal attitudes and behaviours towards people using a wheelchair, and limited financial support for people with disabilities.

Physiotherapy

The participants had mostly positive experiences with physiotherapy. The benefits of physiotherapy were seen as activity-related (being able to dress, write and propel the wheelchair better), promoting general well-being (feeling stronger), providing positive emotions, preventing complications (contractures) and reducing negative symptoms (spasticity). In addition, the importance of a good client-physiotherapist relationship was emphasized: "having one's heart in it", good communication skills, positivity, listening, motivating, friendliness, trust and respecting client's autonomy were mentioned as important qualities in a physiotherapist.

When it comes to negative aspects, there was a general concern about the limited access to physiotherapy, i.e., the participants felt that the government-funded physiotherapy was not sufficient and, at the same time, they could not pay for physiotherapy themselves due to insufficient social benefits.

The aforementioned topics were also mirrored in the participants' recommendations for physiotherapists (and physiotherapy students): they wanted a collaborative relationship, to be motivated to achieve further goals and to be involved in the decision-making process.

Physical activity

All participants found PA to be an important part of their lives and had positive experiences with PA. Nevertheless, their independent activity levels varied greatly: some participated in competitive sports, some exercised independently but not regularly, and PA experiences of some participants were limited to physiotherapy.

They were motivated by several perceived benefits of PA: it provides more functional independence, forms the basis for other activities (e.g., working, sitting for a long time, writing on the computer), promotes general well-being (feeling stronger), provides positive emotions, improves sleep, reduces stress, prevents complications (contractures), and reduces negative symptoms (spasticity, intestinal problems). Those who participated in competitive sports said that it promotes their self-esteem and also provides a social aspect to their lives. Overall, PA was perceived to improve everyday functioning and prevent secondary complications.

Many constraining factors to PA were also identified: lack of financial resources, problems with transportation and accessibility to sports facilities, health problems, pain, lack of motivation, need for assistance (e.g., if a person is unable to transfer independently), lack of time, spasticity, lack of suitable sports to participate in, and functional limitations (associated with the level of injury, e.g., weak/no grip). Thus, the participants identified function- and health-related barriers to PA in addition to motivational and socio-environmental barriers.

DISCUSSION

Disability discourse

It is very common to experience negative feelings, especially immediately after the traumatic SCI [12]. What is more, the traumatic SCI brings about a "biographical disruption" [7] in the participants' lives, i.e., it breaks the illusion of a predictable future and makes people with SCI rethink their values and priorities. This was demonstrated by the fact that all participants divided their life in terms of the traumatic event and expressed the "loss of an able identity" followed by "rediscovering self" which are important steps after traumatic SCI [2, 11]. A prevalent finding from this study and other studies carried out among people with SCI is the importance of peer counseling and mentoring which facilitates the coping process [2, 11].

Limited accessibility expressed by the participants can be problematic both at the individual level because it might hinder coping with SCI [4], and at the societal level because it reflects the attitudes and priorities in the society [11]. One aspect of limited accessibility is limited mobility during the winter months which was a major concern for the participants. Similar problems have also been identified in Canada [13]. This demonstrates how climate conditions have to be taken into account when looking at the barriers/facilitators that people with disabilities face.

However, it should be emphasized that despite these common features each participant had a distinct understanding of disability and the heterogeneity of disability experience is a significant aspect to consider when studying people with disabilities.

Physiotherapy

The positive physiotherapy experiences were described in terms of improving functioning and preventing secondary complications. When it comes to qualities valued in physiotherapists, the results of this study add to the understanding that, in addition to professional competencies, general competencies are very important for health care specialists [15]. One aspect of general competencies is the importance of client-centeredness: if physiotherapists consider their clients' perspectives and thereby increase their involvement and empowerment, this might help to achieve better physiotherapy outcomes.

The main problems related to physiotherapy service are: limited access, irregularity and long waiting lists, which make it difficult to access physiotherapy on a regular basis or according to need. This indicates that access to physiotherapy services according to need might not be guaranteed in Estonia.

Physical activity

Participants were motivated to participate in PA due to different perceived benefits but they also identified several constraining factors, which might hinder their social inclusion if not addressed. It is essential to remove the socio-environmental barriers and thereby increase accessibility to PA. Creating more possibilities for being physically active is the prerequisite for tackling motivational, function- and health-related issues. The heterogeneity of the PA experience of people with SCI should also be taken into consideration, that is, there is no single facilitator or barrier, but rather a unique combination of different factors which justifies the use of a holistic, individual and client-centred approach [9, 11]. This aspect should be taken into account in PA promotion among people with SCI.

Self-efficacy

When looking at why the participants perceived both physiotherapy and PA as beneficial, it can be seen that the four main forms of creating a strong sense of self-efficacy [1] were present: mastery experiences (e.g., increased distance for propelling the wheelchair, using more resistance in strength training), vicarious experiences provided by social models (e.g., other people with SCI engaging in PA), social persuasion (e.g., physiotherapists motivate people to progress in therapy), and enhancement of physical status, reducement of stress and negative emotions and correction of misinterpretations about bodily states (e.g., increased stamina and new acquired skills in physiotherapy and participation in PA). Thus, using the concept of exercise self-efficacy [10] might be beneficial in physiotherapy and PA.

To conclude, the results of this study demonstrate that on the one hand, participants with traumatic SCI faced many similar problems with accessibility, attitudes, physiotherapy, PA etc, but on the other hand, each participant had their own unique set of experiences, reminding us that there is a vast heterogeneity even among a small group of people with a similar condition.

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MUSCULOSKELETAL DISCOMFORT IN PRODUCTION ASSEMBLY WORKERS

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ABSTRACT

The purpose of this study was to analyse subjective self-evaluation of musculoskeletal discomfort conducted by female production assembly workers. Thirty-seven female assembly workers aged 20–54 years participated in this study, whereas 35 of them were right-handed. Discomfort in neck, shoulder, upper back, upper arm, low back, forearm, wrist, hips, thigh, knees, lower legs and heels was subjectively evaluated by Cornell Musculoskeletal Discomfort Questionnaire. The results indicated that female assembly workers felt most work-related discomfort in the neck (44%), lower back (19.7%) and in the right wrist (15%). Discomfort was less pronounced in the right knee (0.01%), left upper arm (0.04%) and left hip buttocks (0.1%). In conclusion, this study indicated that subjective discomfort sensed by female production assembly workers was higher in the neck, lower back, right shoulder and the right wrist. According to the study results, further research is needed on the relationship between musculoskeletal discomfort and its influence on the quality of assembly work.

***Keywords:** physical workload, discomfort, pain*

INTRODUCTION

Global competition in the manufacturing sector has created an environment for continuous improvement, resulting in developing methods to increase capacity while lowering costs. One way for attaining the latter is re-organizing the production by using more effective equipment together with established production practices, e.g. Lean manufacturing or different ISO management standards. Being competitive includes not only the re-organization of production but also paying more attention to the workforce, more specifically the employees' state of health.

In the manufacturing industry the work movements are repetitive and work situations often cause pain in the neck-arm region. These repetitive movements can be pushing, pulling, drawing, reaching, turning, raising, gripping or hitting and most of all this concerns professions such as painter, decorator, riveter, pneumatic tools operator and user of desktop computer [7].

Many occupations require workers to stand for prolonged periods, which can cause both discomfort and pain. Analytical results have demonstrated that the floor type and the work time spent standing significantly affected subjective ratings for leg discomfort and circumferential shank measurements in both laboratory and field studies. Besides, having suitable footwear also significantly affected the employees' subjective ratings for leg discomfort. It can be concluded that footwear and floor conditions and prolonged standing influence workers' lower extremity discomfort. These analytical findings suggest that common ergonomic interventions, e.g. modifying the flooring on which workers stand might alleviate leg edema for workers standing for 4 h-shifts in laboratory and field settings. Nevertheless, prolonged standing for even 1 h without rest showed negative effects and should be avoided when possible [10].

The development of work-related musculoskeletal disorders does not involve only work situations and physical factors, the psychosocial factors are equally important. The work of Eatough et al. [2] supports the notion that psychosocial stressors in work environment have important links to employee health, especially work-related musculoskeletal disorder symptoms. Furthermore, Giuliano and Leonardo [5] described in their study that already Bernardino Ramazzini (1633–1714) recognized the need to undertake measures to prevent disorders from repetitive motions and manual lifting and anticipated the now widely accepted advice of moderation and recommendations of reduction of work duration for a number of hard jobs requiring a standing position or severe muscular effort. From his early writings it is evident that Ramazzini acknowledged the importance of assessing the ergonomic factors associated with the occurrence of work-related musculoskeletal disorders.

The purpose of this study was to analyse musculoskeletal discomfort in production workers at a manufacturing plant and to use these data in the risk assessment of the factory as a preventive action to maintain workers' working ability for a longer period of time.

MATERIALS AND METHODS

Subjects

Thirty-seven females, working as assembly workers, aged from 22 to 54 years (with mean±SE age: 36.4±10.4 years) participated in this study. The mean (±SE) height, body mass and body mass index of the subjects were 166.8±4.2 cm, 61.0±9.5 kg and 21.9±3.7 kg/m^2, respectively and their general employment stage as manufacturing worker was 7.35±5.5 years. Thirty-five workers were right-handed.

The subjects participated in the research voluntarily and the selection of manufacturing workers was random. In the chosen factory was implemented the Lean manufacturing production practice together with a number of ergonomically designed work places. The production process was organized in two shifts. During the 8-hour working day there were two short 10-min breaks for recovery and one 30-min break for lunch. The subjects were familiarized with the essence and the aims of the survey.

Measures

Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) was used in this study. The CMDQ is a 54-item questionnaire containing a body mapdiagram and questions about the prevalence of musculoskeletal ache, pain or discomfort in 18 regions of the body during the previous week (Figure 1). Test-retest reliability for CMDQ at a 3-week interval found a 7% difference in responses for upper body parts and a 1% difference for lower body parts [6]. Respondents indicated the frequency of discomfort on an ordinal scale from 0 (none) to 4 (daily) and severity of discomfort from 1 (slightly uncomfortable) to 3 (very uncomfortable). A pain level of at least "moderately uncomfortable" was selected as a severity threshold for determining prevalence and frequency. The level at which the discomfort interferred with work was scored from 0 (no interference) to 2 (substantial interference). Total discomfort score was calculated by using the following formula: frequency × discomfort × interference = discomfort score.

The questionnaires were filled in at the workplace. The subjects wrote the values of height and body weight themselves and the body mass index (kg/m^2) was calculated.

For the most part of the workday assembly workers sit on a chair or stand behind their working desk, driving screws into the aluminium plate with pneumatic screwdriver (Figure 2). It is important to emphasize that the torque level of pneumatic screwdriver was not recorded.

The diagram below shows the approximate position of the body parts referred to in the questionnaire. Please answer by marking the appropriate box.

		During the last work week how often did you experience ache, pain, discomfort in:					If you experienced ache, pain, discomfort, how uncomfortable was this?			If you experienced ache, pain, discomfort, did this interfere with your ability to work?		
		Never	1-2 times last week	3-4 times last week	Once every day	Several times every day	Slightly uncomfortable	Moderately uncomfortable	Very uncomfortable	Not at all	Slightly interfered	Substantially interfered
Neck		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Shoulder	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Upper Back		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Upper Arm	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lower Back		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Forearm	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Wrist	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Hip/Buttocks		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Thigh	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Knee	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lower Leg	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Foot	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure 1. Cornell musculoskeletal discomfort questionnaire, female version. (Reproduced with permission from the Human Factors and Ergonomics Laboratory at Cornell University). (http://ergo.human.cornell.edu/ahmsquest.html).

Figure 2. Pneumatic screwdriver

Statistical analyses

When processing the data, the standard statistical methods were used for calculating the mean and the standard error (±SE).

RESULTS

Seventy-three percent of the subjects experienced discomfort at or above the moderate severity level in at least one body region in the 7 days prior to questionnaire completion (Table 1). According to the total discomfort score of CMDQ (Table 2), it was concluded that female assembly workers felt discomfort mostly in the neck (44%), lower back (19.7%) and the right wrist (15%), while it was less pronounced in the right knee (0.01%), left upper arm (0,04%) and left hip buttocks (0.1%).

More specifically, the results indicated that 21 (56.7%) workers sensed discomfort in the neck 1–2 times per week or more and 14 of them assessed that this discomfort had a minor effect on their ability to work. Seventeen (46%) workers assessed low back discomfort 1–2 times per week or more and because of this discomfort, 10 (27%) workers estimated that this had a minor effect on their ability to work. The right wrist of production assembly workers was more loaded than other body regions; 14 (37.8%) workers felt discomfort there 1–2 times per week or more and 10 of them sensed that this had a minor effect on their work performance.

Table 1. Subjects' variations of estimating the feeling of discomfort by using CMDQ

Body parts	During the last work week how often did you experience ache, pain, discomfort in:					If you experience ache, pain, discomfort, how uncomfortable was this?			If you experience ache, pain, discomfort, did this interfere with your ability to work?		
	Never	1–2 times last week	3–4 times last week	Once every day	Several times per day	Sightly uncom-fortable	Moderately uncom-fortable	Very uncom-fortable	Not at all	Slightly interefered	Substantially interefered
Neck	14	18	2	1	2	14	8	2	9	14	0
Shoulder_R	26	7	4	0	0	7	3	2	3	9	0
Sholder_L	29	6	2	0	0	6	3	1	2	7	0
Upper Back	29	6	1	0	1	1	6	3	1	8	1
Wrist_R	33	4	0	0	0	3	1	0	1	3	0
Wrist_L	34	3	0	0	0	3	0	0	1	2	0
Lower Back	20	11	5	1	0	7	7	3	5	10	1
Forearm_R	31	3	1	1	1	3	3	0	2	4	0
Forearm_L	34	2	0	1	0	2	0	1	1	1	1
Wrist_R	23	8	2	2	2	9	3	2	4	7	3
Wrist_L	30	3	2	1	1	5	2	0	2	5	0
Hip/Buttocks_R	33	3	1	0	0	3	1	0	3	1	0
Hip/Buttocks_L	33	4	0	0	0	3	1	0	2	2	0
Thigh_R	34	2	0	0	1	2	0	1	2	1	0
Thigh_L	34	2	0	0	1	2	0	1	2	1	0
Knee_R	35	2	0	0	0	1	1	0	1	1	0
Knee_L	32	4	0	1	0	2	3	0	2	3	0
Lower Leg_R	32	3	1	1	1	3	3	0	1	4	1
Lower Leg_L	29	5	1	1	1	3	5	0	1	6	1
Foot_R	34	2	0	0	1	2	0	1	1	2	0
Foot_L	34	2	0	0	1	2	0	1	1	2	0

Table 2. Total discomfort score

Body parts referred to in the questionnaire	Frequency	Discomfort	Interference	Discomfort score	%
Neck	59	36	38	80712	43.89
Lower Back	44.5	29	28	36134	19.65
Wrist_R	48.5	21	27	27500	14.95
Upper Back	22.5	22	20	9900	5.38
Shoulder_R	24.5	19	20	9310	5.06
Lower Leg_L	26	13	16	5408	2.94
Shoulder_L	16	15	16	3840	2.09
Forearm_R	23	15	11	3795	2.06
Lower Leg_R	23	9	12	2484	1.35
Wrist_L	16.5	9	12	1782	0.97
Knee_L	11	8	8	704	0.38
Forearm_L	13	6	6	468	0.25
Foot_R	13	5	5	325	0.18
Foot_L	13	5	5	325	0.18
Thigh_R	13	5	4	260	0.14
Thigh_L	13	5	4	260	0.14
Upper Arm_R	6	5	7	210	0.11
Hip/Buttocks_R	8	5	5	200	0.11
Hip/Buttocks_L	6	5	6	180	0.10
Upper Arm_L	4.5	3	5	68	0.04
Knee_R	3	3	3	27	0.01

DISCUSSION

Several studies have shown similar results to the present study. For example, the physical assessment of 146 female workers in highly repetitive jobs found 54% to have musculoskeletal disorders in the upper limb that were potentially work-related [8]. Many workers had multiple problems, and/or were affected bilaterally (33% of workers). Muscle pain and tenderness was the largest problem, both in the neck/shoulder area (31%) as expected and in the forearm/hand musculature (23%), a previously unreported site [8].

In the study where relationships between a number of ergonomic conditions and product quality in car assembly plant were examined, the results showed that quality deficiencies were three times as common for the work tasks with ergonomics problems, compared with other tasks and an increased risk of quality deficiencies was established for all three categories of ergonomic problems investigated [3]. Direct causes of quality deficiencies were identified, such as discomfort from strained parts of the body, organizational factors and time pressure. The analysis pointed to certain types of tasks that were more likely than others to cause quality problems. The results also showed that an important factor for job satisfaction for the workers was the possibility to perform their tasks with high quality. The study therefore confirms close relationships between ergonomics and quality [3]. Singh et al. [9] found in their study that ergonomically designed equipment reduced physiological and economic costs over others. In another study Dianat et al. [1] investigated the effects of wearing typical industrial gloves on hand performance capabilities (muscle activity, wrist position, touch sensitivity, hand grip and forearm torque strength) and subjective assessments for an extended duration of performing a common assembly task – wire tying with pliers – requiring a combination of manipulation and force exertion. The results showed that wearing gloves significantly increased muscle activity, wrist deviation, and discomfort whilst reducing hand grip strength, forearm torque strength and touch sensitivity.

The causes of cumulative trauma disorders are complex in nature and usually no single factor or simple reason can be determined during work evaluation. Cumulative trauma disorders, also called repetitive strain injuries, have been found to be a major source of occupational disability; their causes and contributing events need to be carefully studied [4].

In conclusion, this study indicated that the feeling of discomfort, subjectively felt by female production assembly workers was higher in the neck, lower back, right shoulder and the right wrist. Further research is needed on the relationship between musculoskeletal discomfort and its influence on the quality of assembly work.

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RANGE OF MOTION AND PAIN INTENSITY OF THE FIRST METATARSOPHALANGEAL JOINT IN WOMEN WITH *HALLUX VALGUS* DEFORMATION AFTER TWO-MONTH HOME EXERCISE PROGRAMME

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ABSTRACT

Hallux Valgus (HV) (also *Hallux abducto valgus*) is a common deformity of the foot, which causes pain, inflammation and decreased joint mobility in the big toe. There are no universally accepted protocol for treating advanced phase *HV,* corrective surgery seems to be the most common direction of curing advanced HV deformation. The purpose of this study was to assess the effects of two-month home exercise programme (HEP) on joint mobility and pain of the first metatarsophalangeal joint (MTP-joint) in women with advanced phase *HV* deformation. Seven women with mean age 55.6±2.9 years with advanced phase HV deformation (first MTP-joint angle more than 20 degrees) participated in the study. Foot pain in different conditions was assessed with modified Foot Function Index's (FFI) pain subscale before and after HEP. Passive range of motion (PROM) of flexion and extension of the first MTP-joint was measured before and after HEP using a standard mechanical goniometer. A significant increase ($p<0.001$) in the passive extension of the first MTP-joint was noted after HEP compared with the joint mobility before HEP, also passive flexion increased considerably but no significant difference was noted ($p>0.05$). Foot pain score decreased significantly ($p<0.05$) after HEP. In conclusion, in advanced phase *HV* two-month HEP was an effective therapeutic approach for increasing first MTP-joint mobility and reducing foot pain.

Keywords: *Hallux valgus, home exercise programme, passive range of motion, foot pain*

INTRODUCTION

Hallux Valgus deformation (*HV*) is multifactorial deformation of the foot where the first metatarsal bone has deviated medially in regards to the midline of the body and the proximal and distal phalanxes have deviated laterally. Resulting from previous there are changes in position of the foot muscles [2, 8]. The deformation is considered to be progressive and irreversible [4, 10]. According to different sources *HV* occurs in about 23% of population [7] and is associated with female gender, older age, and pain in other bodily regions [9]. Some authors refer narrow shoes and high heels as a big promoter for developing *HV* [6]. In mild cases the problem can be only cosmetic, but in more advanced phase there can be pathological changes in gait and plantar pressure, limitations of range of motion (ROM) in foot joints, pain during movement and walking and problems in regards of choosing comfortable shoes [2]. In case of mild to moderate deformation the most common recommendations are to use orthoses; patient is educated about proper footwear and instructed combining orthosis with special exercise and taping, what could alleviate or reduce the symptoms in moderate cases of *HV* deformation [2]. In advanced phase of *HV* corrective surgery is mostly indicated [11]. Surgical osteotomy is found to be an effective treatment for painful advanced phase *HV*, while orthoses provide short-term symptomatic relief [13].

The intervention of physical therapy in the advanced phase of *HV* is considered important mainly in postoperative stage [11]. A few studies are performed to elucidate the effect of physical exercises on the function of foot joints and pain intensity in the advanced phase of *HV* deformation preoperatively. The purpose of the present study was to compare the range of motion and pain in the first metatarsophalangeal joint (MTP-joint) before and after two-month individual exercise program in women with advanced HV. deformation.

MATERIAL AND METHODS

Subjects

Seven female patients aged 50 to 65 years with advanced *HV* deformation (*Hallux Valgus* angle (HVA) more than 20 degrees) and who had appointed to corrective surgery in the next six months volunteered to participate in the study. The mean±SE age of the patients was 55.6±2.9 years, body mass 64.7±10.5 kg, and BMI 24.4±2.6 kg/m^2. The subjects were scheduled to corrective surgery and were evaluated by orthopedic surgeon in the Department of Orthopaedics and Traumatology of Tartu University Hospital. The exclusion criteria included overlapped toes, balance impairments, rheumatoid arthritis and other etiology arthritis, as well as other orthopedic and neurologic diseases, bone fractures in the last year, cognitive disorders and lack of time for the exercise performance. Before the beginning of the testing session, all subjects completed an informed consent form. The study carried the approval of the Ethics Committee of the University of Tartu. All examinations were performed in the Laboratory of Kinesiology and Biomechanics at the University of Tartu twice – before and after the two-month performance of home exercise program (HEP).

Clinical assessment

The subjects' clinical assessment was performed by orthopedic surgeon in the Department of Orthopaedics and Traumatology of Tartu University Hospital. First MTP-joint angle (metatarsophalangeal, HVA) and intermetatarsal (IMA) angle in X-ray imaging of Hallux Valgus foot were calculated (Figure 1A). Reference values for healthy subject are HVA less than 15 degrees and IMA less than 9 degrees [7]. Patients with advanced HV. deformation with HVA of 20 to 40 degrees and IMA of 10 to 15 degrees were recommended for the present study.

Pain questionnaire

For subjective assessment of the foot function modified Foot Function Index (FFI) was used. It consists of three subscales – pain, disability and activity limitations [1]. Foot pain was assessed on a 10-point scale in nine different conditions – pain at maximal level, pain in the morning, pain while walking and standing barefoot, pain while walking and standing with shoes, pain while walking and standing with orthosis and pain at the end of the day. The maximum score was 90 points (p), which indicates the worst condition.

Joint mobility

To measure the passive range of motion (PROM) of the first MTP-joint standard mechanic goniometer was used (Whitehall Manufacturing, USA). The subject was seated on the examination table with feet hanging over the edge, ankle joints in a free position. The axis of the goniometer was placed medially of the first MTP-joint, the proximal end of the goniometer was aligned with the first metatarsal bone and the distal end of the goniometer was aligned with the first proximal phalanx [5]. The first MTP-joint was flexed and extended passively to a maximum range of motion or to the threshold of pain and the reading was fixed (Figure 1B). The measurements were performed three times and best result was documented.

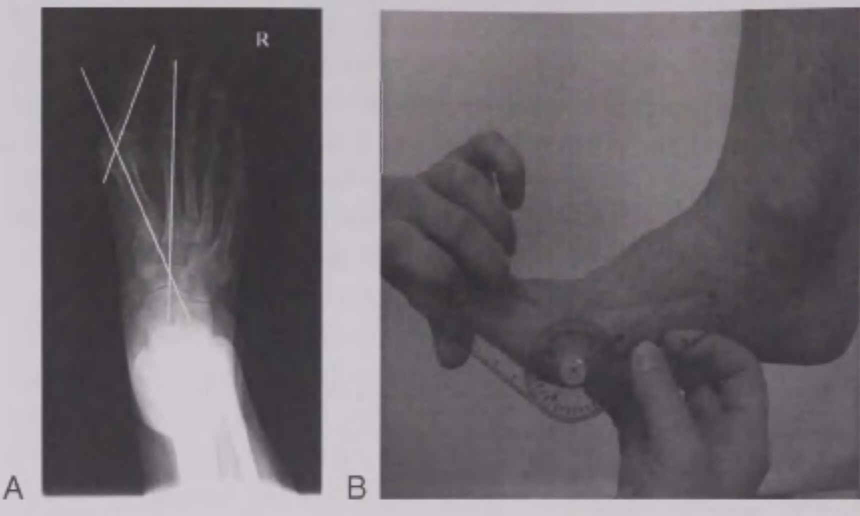

Figure 1. Measurement of first metatarsophalangeal joint angle and intermetatarsal angle in X-ray imaging of *Hallux Valgus* foot of right leg (A), and of passive range of motion of the first MTP joint flexion (B).

Exercise programme

HEP consisted of fifteen special exercises, which were derived from combining the elements of postoperative and mild phase *HV* physiotherapy. The HEP was oriented to improve mobility (9 exercises out of 15) and proprioception (6 exercises out of 15) of the foot and to strengthen the foot muscles (3 exercises out of 15) [2, 11]. At the first meeting the physiotherapist (AA) explained the exercise programme to subjects, gave them the printed exercise programme with pictures and explanations as well as the exercise diary. In the diary they recorded how many times per day they did each exercise, training time, perception of pain before and after the HEP, perceived intensity of the exercise and fatigue during the exercises. To assess fatigue modified Borg scale was used. Subjects preformed HEP twice a day during two months, average exercise time was 20 minutes.

Statistical analysis

Results are expressed as means and standard errors (± SD). Student paired *t*-test was used to evaluate differences in the results of measurements before and after HEP. A level of $p<0.05$ was selected to indicate statistical significance.

RESULTS

The PROM of the first MTP-joint flexion of the affected foot increased 4.3 degrees (29%) and extension increased 17.1 degrees (39%, p<0.001) after two months of HEP (Figure 2). Minimum values of PROM of flexion and extension before HEP were 5 degrees and 35 degrees, respectively, maximum values were 30 degrees and 60 degrees, respectively. Minimum values of PROM of flexion and extension after HEP were 10 degrees and 50 degrees, respectively, maximum values were 30 degrees and 70 degrees respectively. According to Shereff et al [12] the reference values of the PROM of flexion and extension of the first MTP-joint are 34 degrees and 76 degrees, respectively. As compared with reference data the values of PROM of flexion and extension of the first MTP-joint in subjects of the present study with advanced phase *HV* deformation were significantly lower before HEP and increased to the minimum level of the reference values two months after starting HEP.

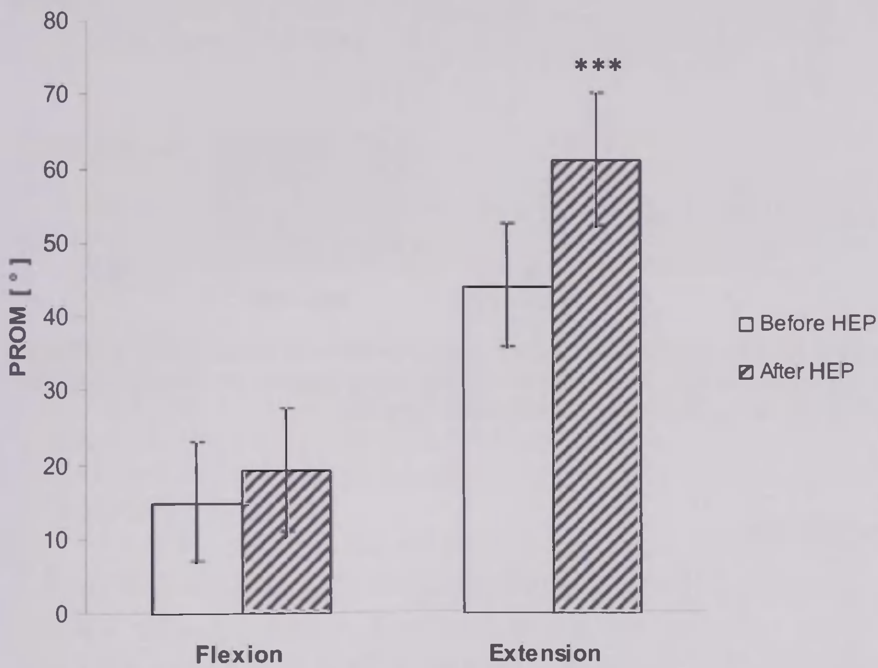

Figure 2. Passive range of motion (PROM) of the first metatarsophalangeal joint flexion and extension before and after two-month home exercise programme (HEP) in women with Hallux Valgus deformation (mean ±SE). ***p<0.001 – significant difference in the PROM extension between pre- and post HEP

Subjects perceived the pain related to the *HV* deformation in very different levels of intensity. The lowest score on the pain subscale of the FFI at the first assessment was 22 p, the highest score was 78 p (the maximum score of FFI pain subscale is 90 p). After the HEP the lowest score of the FFI pain subscale was 9 p, highest score was 48 p. The FFI pain subscale average score in the first assessment was 43.1 p and after HEP 22.4 p – pain decreased on an average of 48% (p=0.03) (Figure 3).

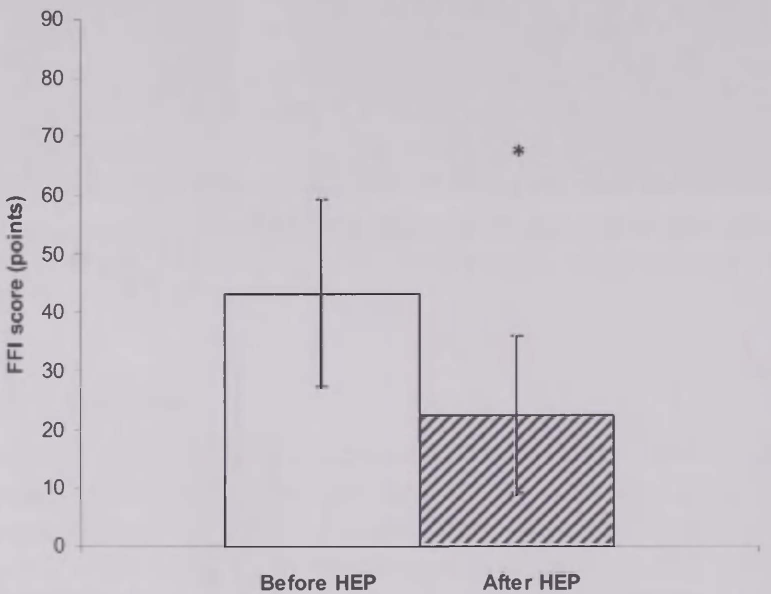

Figure 3. Foot Function Index questionnaire pain intensity score of the first metatarsophalangeal joint before and after two-month home exercise programme in women with Hallux Valgus deformation (mean±SE). *p<0.05

DISCUSSION

The present study compared the range of motion and pain in the first MTP-joint before and after two-month individual exercise program in women with advanced HV deformation. The main findings of the present study were: 1) the PROM of extension of the first MTP-joint increased significantly in women with advanced phase *HV* deformation after two months of HEP and it reached the first MTP-joint reference value; and 2) women with advanced phase of HV deformation reported pain intensity decrease of first MTP-joint after two months of HEP.

In mild phases of *HV* deformation physiotherapy, it is recommended to use orthosis combined with exercises and choosing proper footwear [2], postoperatively lymphatic drainage, cold applications, gait training, mobilization of the MTP-joint, strengthening exercises of the flexors and extensors of toes and manual therapy are applied [10]. In this study both the elements of preoperative and postoperative physiotherapy of *HV* deformation were used [2, 10]. All subjects were very motivated, performed the programme consistently during two months and documented their progress to exercise diary. It was definitely important that women who participated in this study were very interested and participated in the exercise programme regularly.

HV corrective surgery does not always provide total improvement and post-surgery complications may take a long time to recover and surgery is not suitable for every HV patient, so there is a need for studies to test other conservative treatments like exercise programmes, manual therapy, taping and combinations of the previous [3].

In conclusion, this study demonstrated that two-month HEP had a positive effect on foot joint mobility and pain relieving in advanced phase *HV* deformation. It can be recommended to use home exercise programmes in the advanced phase of *HV* deformation before corrective surgery.

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INFLUENCE OF HOME EXERCISE PROGRAMME ON THIGH MUSCLE TONE AND FUNCTION OF KNEE JOINT BEFORE TOTAL KNEE ARTHROPLASTY

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ABSTRACT

The aim of the study was to investigate the effect of 8-week home exercise programme (HEP) on thigh muscle tone in patients with knee joint osteoarthritis (OA) before total knee arthroplasty (TKA). Fifteen female patients with knee joint OA aged 50–74 years who were scheduled to TKA participated in the study before and after 8-week HEP. Muscle tone (frequency of muscle oscillation), elasticity (logarithmic decrement of muscle damped oscillations) and stiffness of *rectus femoris, vastus medialis* and *vastus lateralis* muscles were measured using hand-held myotonometer Myoton 3. Self-reported assessment of knee joint function and pain was performed using Western Ontario McMaster Universities Osteoarthritis Index (WOMAC). Significant ($p<0.05$) decrease in muscle tone and stiffness of *vastus lateralis* muscle was noted after HEP, but no change was observed in elasticity of the muscle. Also no significant difference was found in *rectus femoris* and *vastus lateralis* muscles in either tone, elasticity or stiffness. As a result of 8-week HEP, pain intensity in knee joint decreased, whereas self-reported function of knee joint by WOMAC did not improve significantly. Preoperative performance of HEP is recommended for improvement of surrounding knee joint muscle function.

Keywords: *osteoarthritis, muscle tone, home exercise programme, WOMAC index*

INTRODUCTION

Osteoarthritis (OA) is one of the most common diseases affecting joints and causing loss of functional ability among elderly people and the disease most commonly affects knee joints. The risk factors of the disease are age, female gender, obesity, trauma, genetical predisposition and muscle weakness. The main symptoms are pain, joint stiffness, swelling, joint instability and muscle weakness, which can lead to impaired physical and emotional condition and reduced quality of life [5, 3].

Total knee arthroplasty (TKA) is an intervention for people with severe OA when conservative therapy has no effect. Patients often have to wait several months for the surgery and during that time they endure severe pain that restricts their activities of daily living (ADL) and participation in their normal social roles. Pre-operative interventions such as exercises are performed in the expectation of improving pre-operative outcomes as well as recovery after surgery [20]. There is much evidence suggesting that exercises are effective in OA patients for decreasing pain and improving function [5, 3]. Not much research has been done about the effect of exercises in OA patients waiting for knee replacement surgery [20].

There is no evidence in the literature about muscle tone measurement in OA patients.

Muscle tone of *quadriceps femoris* muscle has been previously studied in healthy older males [1] and adult male basketball players [12], as well as other lower limb muscles in young male athletes [10, 11]. There has been one study that investigated muscle tone of *quadriceps femoris* muscle after arthroscopic partial menisectomy in males and females [6]. However, muscle tone is a very important criterion, when determining the function of the skeletal muscle [21, 19]. A special device for measuring muscle tone – myotonometer – was developed at the University of Tartu. Its validity and reliability have been scientifically proven [4, 22]. The working principle of the device is based on recording the damped oscillation of tissue after a short calibrated mechanical impulse on the muscle belly [1, 18].

The aim of the present study was to investigate changes in thigh muscle tone and function of knee joint in OA patients waiting for TKA before and after an 8-week home exercise programme (HEP).

MATERIALS AND METHODS

Subjects

Thirteen female patients aged 50–74 years with late stage of knee joint OA who were scheduled for total arthroplasty of the knee joint volunteered to participate in the study. The mean±SD age of the patients was 62.3±7.2 years, body mass was 91.3±15.9 kg and body mass index was 34.7±6.0 kg/m^2. The subjects were scheduled to surgery and evaluated by orthopaedic surgeon in the Department of Orthopaedics and Traumatology of Tartu University Hospital. The exclusion criteria were other musculoskeletal diseases, neurological diseases and diseases affecting balance and coordination. On the day of the assessment the subjects had not taken any inflammatory or pain relieving medication and all testing was conducted in the morning time from 9 to 11 am. Before the beginning of the testing session, all subjects completed an informed consent form. The study carried the approval of the Ethics Committee of the University of Tartu. The testing was performed in the Laboratory of Kinesiology and Biomechanics of the University of Tartu twice – before and after the 8-week HEP.

Measures

Clinical investigation

The subjects' clinical investigation was performed by orthopaedic surgeon (TH) in the Department of Orthopaedics and Traumatology of Tartu University Hospital. Knee joint osteoarthritic changes were evaluated in X-ray imaging and patients with late stages of OA (stage III–IV according to Kellgren and Lawrence [8] classifications) who were scheduled for knee joint replacement and had no above mentioned exclusion criteria were recommended for participation in the present study.

Exercise programme

The preoperative therapeutic HEP was mostly oriented to muscle strengthening exercises with elastic band (Thera-Band, System of Progressive Exercise, US), stretching, balance and walking exercises. At the first meeting the physiotherapist (JS) explained the exercise programme to the patients, gave them the elastic band set, the printed exercise programme with pictures and explanations, and diary. In the diary they recorded how many times per day they did each exercise, training time, perception of pain before and after the HEP, perceived intensity of the exercise and fatigue during the exercises using modified Borg scale, time spent in outdoor walking, and the number of stairs walked during the day. Once a week the physiotherapist called the patients on the phone, and asked them about HEP and problems with the knee. The patients performed the HEP once a day during 64 days (whereas one patient did the exercises twice a day) on the average with mean exercise time duration of 35 min.

Muscle tone measurement

For muscle tone, elasticity and stiffness characteristics investigation the hand-held myotonometer Myoton 3 (Müomeetria Ltd, Estonia) was used [13, 15, 17]. The working principle of device is based on dosed impact on muscle belly, after which a muscle as viscous-elastic structure reply with damped oscillation. The muscle tone is characterized by frequency of muscle oscillation [Hz]. The muscle elasticity, i.e. the ability of the muscle to restore its initial shape after contraction, is characterized by logarithmic decrement of oscillations' amplitude damping [14, 16]. Muscle with high elasticity has lower logarithmic decrement value. Stiffness of muscle characterized the ability of tissue to restore its shape after removing of external force acting on muscle. Myoton 3 has mass of testing end 18 g and it induces oscillation of muscle tissue by a mechanical impact with minimal force (up to 0.4 N). The diameter of Myoton 3 testing end was 3 mm and stroke time of testing end of device during all measurements was 15 ms. Previously it has been found that the acquired data of muscle tone, elasticity and stiffness did not depend on the measurer [19] and good reliability of device was noted [4].

Following knee extensor muscles were investigated: *m. rectus femoris (RF), m.vastus medialis (VM)* and *m.vastus lateralis (VL)*. The area for measurements (the middle part of muscle belly) was identified by manual palpation at muscle contraction [9, 18, 7]. The testing end of myotonometer was placed on previously palpated muscle belly. Points for measurements has been marked by marker symmetrically for muscles of right and left body side. Registering tone characteristics of the observable person was in supine position (Figure 1). The muscle tone characteristics were evaluated at rest using MultiScan mode of myotonometer performing 5 measurements in each muscle before and after 8-week HEP. Data were analysed using software Myoton® and mean value from 5 measurements were accepted for future analysis.

Self-reported knee function assessment

Patients assessed their knee joint function using Western Ontario McMaster Universities Osteoarthritis Index (WOMAC) questionnaire which are used for patients with knee joint OA. Questionnaire consists of 24 questions (5 for pain, 2 for stiffness and 17 for physical function of knee joint) [2]. WOMAC index values are in range of 0 (worst) to 100 (best).

Figure 1. Measurement of thigh muscle tone by myotonometer Myoton 3

Statistical analysis

Data are mean and standard deviation (±SD). A paired t-test was used to evaluate differences between pre- and post-HEP session. A level of $p<0.05$ was selected to indicate statistical significance.

RESULTS

Data of the muscle tone, elasticity and stiffness characteristics are presented in Tables 1, 2 and 3, respectively.

Table 1. Muscle tone characteristics (frequency of muscle oscillation) in women with knee OA before and after 8-week HEP

Muscle	Frequency (Hz)							
	Before HEP				After HEP			
	Mean±SD	Min	Max	Median	Mean±SD	Min	Max	Median
M. rectus femoris								
Affected	11.41±1.46	8.78	13.54	11.58	11.32±1.58	8.56	14.94	11.32
Non-affected	11.56±1.76	8.86	15.06	11.58	11.45±1.94	8.66	15.42	11.48
M.vastus medialis								
Affected	10.31±1.06	8.56	12.04	10.06	10.52±1.25	8.68	12.44	10.32
Non-affected	10.54±1.21	8.76	12.90	10.40	10.48±1.19	8.94	11.7	10.22
M.vastus lateralis								
Affected	11.29±2.75	7.58	17.00	11.24	10.29±1.77*	8.10	14.34	10.12
Non-affected	11.28±2.45	7.40	17.00	11.60	10.68±1.89*	8.60	15.10	10.90

Note: HEP – home exercise program, SD – standard deviation, min-minimum, max-maximum, *$p<0.05$ as compared pre- and post-HEP

Table 2. Muscle elasticity characteristics (logarithmic decrements) in women with knee OA before and after 8-week HEP

Muscle	Decrement							
	Before HEP				After HEP			
	Mean±SD	Min	Max	Median	Mean±SD	Min	Max	Median
M. rectus femoris								
Affected	1.80±0.32	1.41	2.46	1.77	1.85±0.23	1.44	2.27	1.84
Non-affected	1.69±0.33	1.24	2.23	1.69	1.77±0.22	1.33	2.05	1.81
M.vastus medialis								
Affected	1.33±0.05	1.09	1.52	1.29	1.38±0.22	0.96	1.83	1.34
Non-affected	1.36±0.12	1.14	1.72	1.33	1.32±0.19	0.99	1.75	1.30
M.vastus lateralis								
Affected	1.50±0.27	1.06	2.13	1.49	0.10±0.21	1.23	1.83	1.48
Non-affected	1.51±0.26	1.06	1.93	1.42	1.51±0.22	1.13	1.96	1.41

Note: HEP – home exercise program, SD – standard deviation, min-minimum, max-maximum. Muscle with high elasticity has lower logarithmic value

Table 3. Muscle stiffness characteristics in women with knee OA before and after 8-week HEP

Muscle	Decrement							
	Before HEP				After HEP			
	Mean±SD	Min	Max	Median	Mean±SD	Min	Max	Median
M. rectus femoris								
Affected	192.89±31.17	148.60	255.20	184.40	186.25±33.33	130.20	267.20	191.00
Non-affected	189.48±33.59	145.40	243.20	178.00	186.73±35.86	131.00	259.20	186.60
M.vastus medialis								
Affected	177.52±22.68	146.20	219.80	175.80	179.64±31.66	128.40	238.80	181.20
Non-affected	183.53±29.57	148.00	250.60	180.20	173.72±29.33	127.20	248.00	177.00
M.vastus lateralis								
Affected	178.88±12.47	115.00	261.40	253.60	168.47±34.80*	117.60	250.40	168.00
Non-affected	184.60±6.13	124.60	288.00	183.90	171.07±40.92*	115.00	274.00	175.00

Note: HEP – home exercise program, SD – standard deviation, min-minimum, max-maximum; *p<0.05 as compared pre- and post-HEP

Tone, stiffness and elasticity of *RF* and *VM* muscles did not differ significantly ($p>0.05$) after 8-week HEP as compared to before. Muscle tone and stiffness characteristics of *VL* muscle decreased significantly ($p<0.05$) after 8-week HEP. There was noted no statistically significant difference in muscle tone, stiffness and elasticity between the affected and non-affected leg before and after 8-weeks HEP.

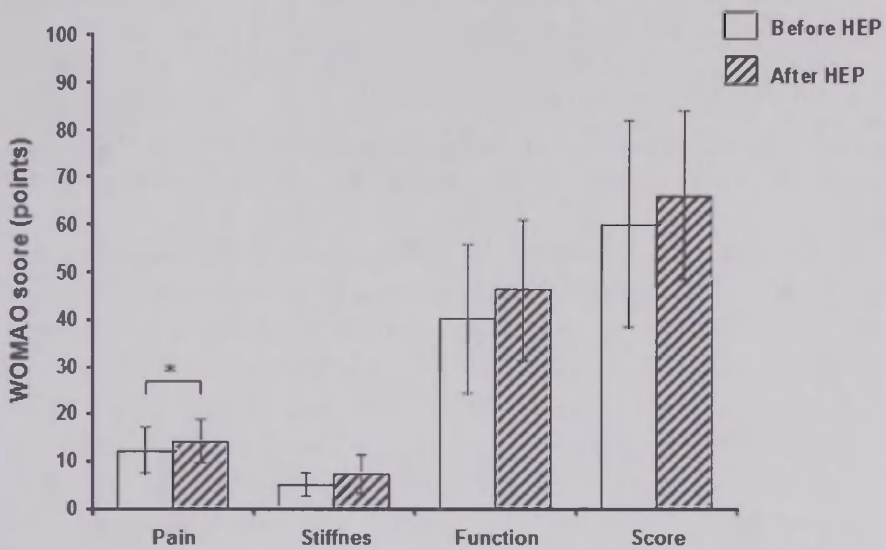

Figure 2. WOMAC index for self-reported assessment of pain, stiffness and function of the knee joint as well as total score in women with knee OA before and after 8-week HEP. Higher score indicates better condition of the knee joint. (mean±SD), *$p<0.05$

In the present study a statistically significant decrease ($p<0.05$) of knee joint pain was noted after 8-weeks HEP, whereas there was no changes in the total score of WOMAC index (Figure 2).

DISCUSSION

The reference values of muscle tone, stiffness and elasticity are individually specific, varying remarkably between test subjects and between muscles [18, 19]. Therefore it is recommended to follow reference values when evaluating the results, also trends of parameters (changes in time) should be considered. Variability of a characteristic is very informative in a longitudinal study [18]. In the present study range of different characteristics was found. Taking all of the results in to calculation both before and after 8-week HEP, the range of frequency of muscle oscillation were: for *RF* muscle 11.4–15.06 Hz, *VM* muscle 8.56–12.9 Hz, *VL* muscle 7.4–17 Hz. Reference value of frequency of muscle oscillation of non-pathological muscles is 11–16 Hz [18]. When comparing the results of the present study with the reference value of frequency of muscle oscillation it was noted that all measurements of muscle tone characteristics were within the reference value range.

In the present study the ranges of logarithmic decrements for *RF* muscle were 1.24–2.46 (mean 1.78), for *VM* muscle 0.96–1.83 (mean 1.35), for *VL* muscle 1.06–2.13 (mean 1.49). Reference values of logarithmic decrements are below 1.0–1.2 [18]. Lower logarithmic decrement values demonstrate higher elasticity of muscle. It can be concluded that in present study the elasticity of muscles of OA patients was lower as compared to healthy subjects' reference data.

Values of muscle stiffness for *RF* muscle in OA patients were 130–267 N/m (mean 189 N/m), for *VM* muscle 127–251 N/m (mean 179 N/m), for *VL* muscle 115–288 N/m (mean 176 N/m). The range of muscle stiffness reference value is 150–300 N/m [18]. Unfortunately there were no similar studies in the literature for the comparison of changes in muscle tone characteristics after 8-week HEP in women with knee OA. In a recent study by Aird and colleagues [1] no statistically significant difference between mechanical properties (tone, elasticity and stiffness) of *m. quadriceps femoris* in the dominant and non-dominant leg was found in healthy male subjects measured by MyotonPRO myotonometer (Myoton AS, Estonia).

We can conclude that after 8-week HEP patients with knee joint OA had significant decrease of muscle tone and stiffness in *m. vastus lateralis* affected and non-affected thigh. There was noted no significant difference in measured characteristics of other studied muscles of neither affected nor non-affected leg. The measured characteristics also did not differ significantly between legs. It could be proposed that osteoarthritic changes are presented in patients knee joints bilaterally, but in different levels. As a result of 8-week HEP, pain intensity in knee joint decreased, whereas self-reported function of knee joint did not improve significantly. Similar results of the WOMAC index score have also been found by previous studies with patients with knee OA [20]. Preoperative performance of HEP is recommended for improvement of surrounding knee joint muscle function. Future study should be carried out to elucidate which kind of exercise influence the increase of muscle function in knee joint OA patients before TKA with aim to accelerate postoperative recovery.

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ACTIVITY OF SHOULDER MUSCLES DURING SHOTS OF DIFFERENT DIFFICULTY LEVEL IN MORE AND LESS SKILLED NOVUS PLAYERS

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ABSTRACT

The aim of the present study was to compare the activation of the shoulder muscles in more and less skilled novus players during shots of different difficulty level. Nineteen competitive novus players (9 more skilled and 10 less skilled) were recruited to examine bioelectrical activity of the shoulder muscles (trapezius, deltoid lateral and posterior muscles) during a striking accuracy task. Participants performed 3 series, each consisted of 10 novus shots – 10 penalties, 10 cut and 10 rebound shots. Surface EMG (sEMG) amplitude of posterior and lateral deltoid and trapezius muscle of the subjects' dominant side was measured during the shot and compared between successful versus unsuccessful shots in more skilled and less skilled players. Unsuccessful penalties and rebound strokes compared to successful ones in more and less skilled players, and unsuccessful cut shots compared to successful ones in more skilled players are characterized by higher activity in trapezius muscle. Higher activity of trapezius muscle is a characteristic feature of less skilled players' novus shots. During successful penalties, cut and rebound shots the sEMG amplitude of trapezius muscle in more skilled players was significantly lower (34%; $p<0.05$; 19%; $p<0.001$ and 60%; $p<0.01$, respectively) than in less skilled players.

Key words: *cuesports, electromyography, bioelectrical activity, expert-novice differences*

INTRODUCTION

In cuesports it is considered quite natural that the players with higher qualification exceed their less skilled opponents in the accuracy of shots. Proof to that widespread point of view can also be obtained from previous studies [7, 11]. It has been verified that more accurate shots are not the result of better vision – visual acuity of experts is no better than that of novices and intermediate players [1]. The fact that experts are better decision makers, can recall, recognise, and assess various sophisticated situations more easily and plan ahead more successfully [1] does not help them either when the players have to perform just a simple shot. A quite frequent mistake of novices is a too heavy stroke [9]. Wall and Crimi [10] considered the most difficult in committing a shot the choice of stroke force. Analysis of impact velocity measures showed that cue velocity of expert and novice snooker players differed significantly [7]. Experts demonstrated more consistent velocity of the cue from shot to shot compared to novices. Besides that, vertical impact velocity of the stroke which ideally should be zero was significantly lower in experts than in novices. The authors explained their result with an opinion that the experts had acquired necessary movement patterns and also with the improvement of handling the cue, minimal deflection of it during the stroke [7]. Taking into consideration prior findings we can assume that carrying out a successful shot depends greatly on the skill of handling the cue and there is a great probability that this is conditioned by one's muscle recruitment.

Electromyographic (EMG) data of skeletal muscles' activation and its differences when comparing experts and novices has been studied in several sports like archery [4], cycling [3], badminton [8], tennis [5], and golf [2]. In a golf expert-novice comparison no significant differences were found between the EMG records of the two groups [2]. Even more – there was considerable inter-subject variation amongst the expert subjects. Nevertheless, experts' individual muscle activation patterns were remarkably consistent from trial to trial. The authors concluded that there were different combinations of muscle action that could be used to produce similar kinematics [2]. However, differences in EMG data have been found not only between athletes of different qualification levels [3, 4, 5, 6, 8] but also between successful and unsuccessful performance [6, 8]. Chapman et al. [3] explained the differences between the EMG data of experienced and novice cyclists with the skilled and masterful movement of highly qualified athletes and considered probable that it was the result of neuromuscular adaptation acquired during long-time workout. To the best of our knowledge, there has been no experimentation of how muscle recruitment helps to succeed striking in cuesports. The aim of this study was to compare the bioelectrical activity of trapezius, posterior deltoid and lateral deltoid muscles during shots of different difficulty level in more and less skilled novus players.

MATERIALS AND METHODS

Subjects

Nineteen novus players (5 female and 14 male) participated in the study. The subjects were distributed into two groups according to their year 2010 competition results: 1) highly skilled (2 female and 7 male; mean age 47.89 years, range 24–63 years) and 2) less skilled (3 female and 7 male; mean age 35.5 years, range 13–67 years) novus players. The members of the highly skilled group have frequently shown high results in international competitions, 3 of them (2 female and 1 male) have been European champions. The average playing experience of more skilled players was 28.3 years (ranging 13–43 years) and of less skilled players 7.1 years (ranging 2–28 years).

Measures

Measurement of muscle bioelectrical activity

Surface EMG (sEMG) was used to measure the bioelectrical activity of trapezius and deltoid muscles during different novus shots. sEMG activity of the muscle activation was recorded by 16-channel electromyograph ME6000 Mega Electronics and software Megawin (Finland). Bipolar sEMG electrodes (Noraxon, USA) were placed on the following muscles on subjects' dominant body side: posterior and lateral deltoid (4–5 cm below acromion) and trapezius muscle (middistance between cervical vertebra C_7 and acromion). In order to prevent shifting, wires between the electrodes and the amplifier were fixed to the subjects' body with a tape. Bioelectrical (sEMG) activity (μV) of the shoulder muscles was registered during unsuccessful (Figure 1A, 1C) and successful (Figure 1B, 1D) strokes in less and more skilled novus players. Peak amplitude during the shot was measured.

Performance outcome estimation

The participants had to commit 3 series, each consisting of 10 novus shots – 10 penalties, 10 cut and 10 rebound shots. The placement of the discs (only one disc on the board at a time) was the same within one series and for all participants. The subjects were asked to perform as well as they could and to pocket as many discs as possible. During the strokes the performance outcome (successful eg a pocketed disc / unsuccessful eg a missed shot) was registered for each attempt.

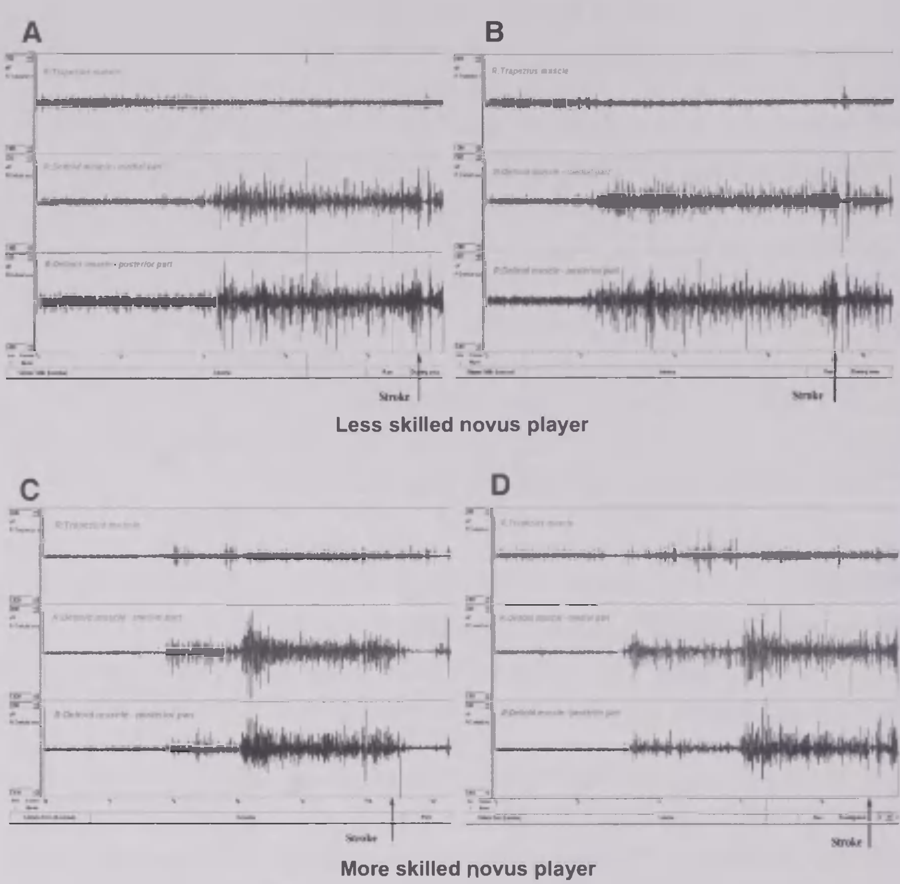

Figure 1. Bioelectrical (sEMG) activity (μV) of the shoulder muscles during unsuccessful (A, C) and successful (B, D) penalty shot in less and more skilled novus players. Vertical line–moment of stroke, before it–stroke preparation phase; after it–stroke phase and relaxation phase. More skilled player in stroke preparation phase have initially more relaxed shoulder muscles and specific pre-stroke muscles activation as well as post-stroke muscles relaxation. Trapezius muscle–upperline, lateral deltoid muscle–middle line and posterior deltoid–lower line

Experimental design

The study was carried out at the Laboratory of Kinesiology and Biomechanics of the University of Tartu in 2011. For the experiment internationally accepted novus board with a playfield size 100 x 100 cm and pockets with a diameter 100 mm were used. Players used their own cues and strikers. The strikers were weighed in order to ascertain their weight corresponds to the international novus regulations. At first sEMG electrodes were fixed to subjects' dominant body side on shoulder muscles: posterior and lateral deltoid and trapezius muscles. Then the subjects were thoroughly explained the shots they had to commit. Before carrying out the test each subject had 15 minutes for practising. During the shots sEMG parameters were measured.

Statistical analysis

Data are expressed by means and standard error of mean (±SE). The significance of the differences between the two groups of subjects and between successful versus unsuccessful shots was analyzed by the unpaired Student t-test. A level of $p<0.05$ was selected to indicate statistical significance.

RESULTS

In more skilled players the peak EMG amplitude of trapezius muscle ($p<0.05$), lateral deltoid ($p<0.01$) and posterior deltoid muscles ($p<0.05$) during successful performing of penalties was significantly lower (34%, 61%, and 61%, respectively) than in less skilled players (Figure 2A). Analogous difference between highly skilled and less skilled players was observed in trapezius ($p<0.01$) and posterior deltoid ($p<0.001$) muscles during unsuccessful shots.

More skilled players had lower sEMG peak amplitude during successful penalty shot as compared to unsuccessful penalties in trapezius ($p<0.01$), lateral deltoid ($p<0.001$), and posterior deltoid ($p<0.001$) muscles – 40%, 91%, and 34% respectively. Similar differences in sEMG peak amplitude values were found in less skilled players – its values during successful shots were 16% in trapezius ($p<0.001$) and 56% in posterior deltoid ($p<0.001$) lower than at unsuccessful shots.

During successful cut shots the sEMG amplitude of trapezius muscle in more skilled players was significantly lower (19%; $p<0.001$), but the amplitude of lateral and posterior deltoid muscles was higher (27%; $p<0.05$ and 39%; $p<0.001$, respectively) than in less skilled players (Figure 2B). Also, a significant increase of the sEMG amplitude of trapezius muscle during unsuccessful cut shots in more skilled players' successful and unsuccessful shots was found (188%; $p<0.01$) – it was higher as compared with successful cut shots.

The analysis of sEMG data measured during the rebound stroke revealed that the sEMG amplitude values in trapezius muscle of less skilled players were significantly higher than the values of more skilled players during both successful and unsuccessful shots (60%; $p<0.01$ and 115%; $p<0.001$, respectively) (Figure 2C). Higher values of sEMG amplitude were also observed in unsuccessful compared to successful rebound shots in more skilled players' trapezius (97%; $p<0.01$), lateral deltoid (32%; $p<0.05$) and posterior deltoid (56%; $p<0.05$) muscles, as well as in less skilled players' trapezius (166%; $p<0.001$) and lateral deltoid (24%; $p<0.05$) muscle.

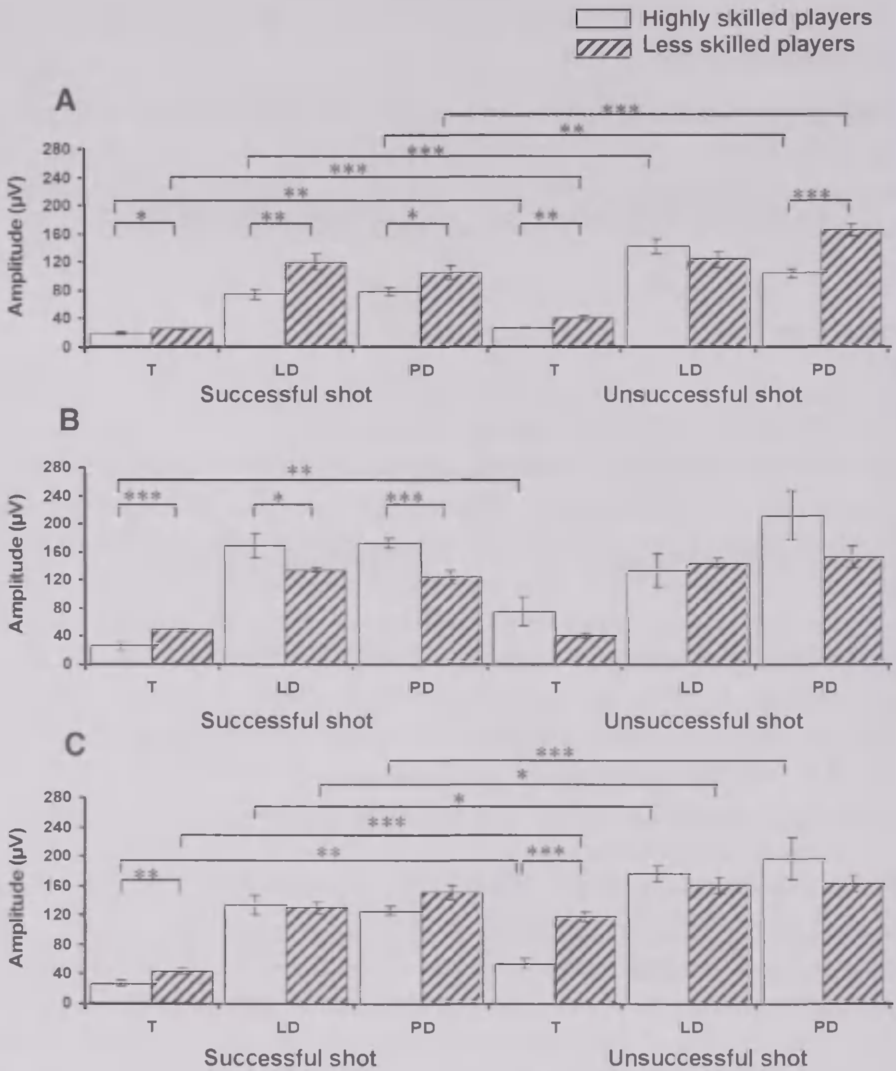

Figure 2. Peak amplitude of bioelectrical activity of the shoulder muscles in more and less skilled novus players during different kinds of successful and unsuccessful shots: A – penalty, B – cut shot, C – rebound shot, T – trapezius muscle, LD – lateral deltoid muscle, PD – posterior deltoid muscle (mean±SE). *$p<0.05$; **$p<0.01$; ***$p<0.001$

DISCUSSION

The present study investigated differences in bioelectrical activity of shoulder muscles during different kind of novus shots in more and less skilled athletes. The main finding of the study was that unsuccessful penalties and rebound strokes in more and less skilled novus players and cut shots in more skilled players are characterized by higher activity in trapezius muscle. The sEMG amplitude of trapezius muscle during successful penalties, cut and rebound shots in more skilled players was 40% ($p<0.01$), 188% ($p<0.01$), and 97% ($p<0.01$), respectively, lower than at unsuccessful shots. Besides that, we can say that the higher activity of trapezius muscle is a characteristic feature of less skilled players' novus shots. During successful penalties, cut and rebound shots the sEMG amplitude of trapezius muscle in more skilled players was significantly lower (34%; $p<0.05$; 19%; $p<0.001$ and 60%; $p<0.01$, respectively) than in less skilled players.

More accurate shot of experts and the ability of highly skilled players to direct the cue in the desired direction [7, 11] could be connected with efficient muscle recruitment acquired during long-time practice. Too high activity of trapezius, posterior deltoid and lateral deltoid muscles could be one of the reasons for the failure of a shot. Differences in sEMG values of more skilled and less skilled novus players refer to the fact that players with higher qualification have acquired a skill to use trapezius and deltoid muscles with a different activation pattern than the less skilled players do. The results of the current study support the assumption that differences in EMG activity values between experts and athletes with lower qualification are the result of neuromuscular adaptation acquired during long-time workout [3].

Expert-novice differences have been a popular topic for quite long time. Muscle activation differences between more and less qualified athletes have been studied [2, 3, 4, 5, 8] but still not much is known. Present study helped to get an insight into shoulder muscle activation pattern during a stroke in cuesports. Better understanding of how athletes with higher qualification differ from their less skilled opponents helps to find ways for more effective training.

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PERCENTILE SCALES FOR ANALYSIS OF BODY COMPOSITION IN MALE YOUTH

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ABSTRACT

For the purpose of present study five thousand adult males were selected randomly as subjects for the study. The age of subjects were ranging from 18–25 years. On the basis of chronological age, subjects were divided into eight different age groups: 18 years (n=640), 19 years (n=960), 20 years (n=760), 21 years (n=560), 22 years (n=540), 23 years (n=520), 24 years (n=509) and 25 years (n=511). Following variables were selected for the purpose of present study: body fat percentage, fat mass and skinfold thicknesses (*chest, triceps, subscapular,* and sum of skinfolds). The scores for each variable were gathered for all the subjects separately and then pooled agewise. Percentile scales were constructed to prepare the standards for body composition. Percentile scales were prepared for different age groups for the college youth of Delhi State. The percentile scales provide a basis for interpreting an individual's score in terms of his standing in some specified group. However, percentile scale is not considered a standard scale as the mean and standard deviation are not used in constructing the scale and the scores are not distributed evenly.

Keywords: *body composition, body fat percentage, percentile scales, male youth*

INTRODUCTION

History points that the people who cared for their bodies and engaged in vigorous physical activities, remained strong and prosperous, whereas those neglected them, waned and perished [8]. The importance of good body composition in the achievements and maintenance of good health cannot be underestimated. Obesity has become a health hazard of epidemic proportion in most developed countries around the world. Obesity by itself has been associated with several serious health problems and account for 15 to 20% of the annual US mortality rate. Obesity has long been recognized as a measure of risk factor for diseases of the cardiovascular system, including coronary heart disease, hypertension, congestive heart failure, elevated blood lipids, athero-sclerosis, strokes, varicose veins and intermittent claudication. The proper way of determining ideal body weight is through body composition, that is by finding out what percent of total body weight is fat and what amount is lean tissue. The importance of good body composition in the achievement and maintenance of good health cannot be underestimated [3].

It is important to assess both weight and percent body fat because they provide two related pieces of information about a person's body composition. Body weight is easy to measure and once someone has an understanding of a desirable body weight for his or her frame, weight can be used to monitor changes in body composition. The shortcoming of using only body weight is that the lean weight component, frame size and muscle development are not accurately considered. Two individuals of the same height, gender and age may weigh the same, but have different levels of lean mass and body fat [1].

In general body fatness negatively influences performances both mechanically and metabolically in most physical tasks that require translocation of body weight. Fat free weight on the other hand, tends to have a positive relation with physical performance. Body size and body composition are important factors determining one's performance ability. In general, body fat negatively influences athletic performances involving agility, speed, endurance, running and jumping. On the other hand, the fat free body mass is positively associated with and may be required for athletic activities in which force must be applied such as lifting, pushing, throwing and blocking [2].

Scientists usually divide the body into four components- water, bone tissue, protein tissue and fat tissue. Body composition may be condensed in two components – body fat and lean body mass. Body fat is the total amount of fat in the body. Lean body mass primarily consists of the muscles and bones and other body organs such as the heart, liver and kidneys. Body composition may be influenced by a number of factors such as age, sex, diet and exercise. Age effects are significant during development years. Diet can affect body composition over a short period such as in the acute water restriction and starvation but its main effects are seen over long periods [7].

Skinfolds are practical values of body composition or relative fatness/leanness, which provide a more accurate estimate of body fatness than simple weight, height and various ratios of these two measurements [4]. Skinfolds measurements are highly correlated with underwater determined body density. Multiple regression models have been used to develop generalized skinfold equations for men [1]. Abdominal skinfolds in men and thigh skinfolds in women are difficult for some technician to measure [2]. Hence in the present study generalized equation developed by Jackson & Pollock [1] using sum of three skinfolds (*chest, triceps* and *subscapular*) was adopted. For any evaluation procedure where the performances can be obtained in terms of numerical scores, it is necessary that a standard scale be available to interpret such scores without which the scores may not convey much meaning [5]. The objective of this study was to establish and compare the body composition standards of college youth of Delhi State on the basis of their age.

MATERIALS AND METHODS

For the purpose of present study five thousand adult males of Delhi State, India were selected randomly as the subjects for the study. The age of the subjects were ranging from 18–25 years. Subjects were from various colleges of Delhi State. On the basis of chronological age, subjects were divided into eight different age groups namely: above 18 years (n=640), 19 years (n=960), 20 years (n=760), 21 years (n=560), 22 years (n=540), 23 years (n=520), 24 years (n=509) and 25 years (n=511). Following variables were selected for the purpose of present study: body density, body fat percentage, lean body mass, fat mass and skinfold thicknesses (*chest, triceps, subscapular,* and sum of skinfolds). The scores for each variable were gathered for all the subjects separately and then pooled age wise. Percentile scales were constructed to prepare the standards for body composition. For the purpose of analysis of data, Microsoft Excel 2000 was used to prepare the percentile scales.

RESULTS

The data was analysed and standards of body composition were prepared and presented in the form of percentile scales. The result shows that the lowest body fat percent was found in 18 years age group while the highest percent of body fat was found in 25 years of age group. Similarly, the fat mass was also found to be lowest in 18 years of age group as compared to 25 years of age group.

Table 1 show that lowest value of body fat percentage is at 100th percentile, while the highest value of body fat percentage is at zero percentile for different age groups. Table 2 shows that the lowest value of fat mass is at 100th percentile, while the highest value of fat mass is at zero percentile for different age groups. Table 3 shows that the highest value of lean body mass is at 100th percentile, while the lowest value of lean body mass is at zero percentile for different age groups. Table 4 shows that lowest value of chest skinfold is at 100th percentile, while the highest value of chest skinfold is at zero percentile for different age groups. Table 5 shows that lowest value of triceps skinfold is at 100th percentile, while the highest value of triceps skinfold is at zero percentile for different age groups. Table 6 shows that lowest value of subscapular skinfold is at 100th percentile, while the highest value of subscapular skinfold is at zero percentile for different age groups. Table 7 shows that lowest value of sum of skinfold is at 100th percentile, while the highest value of sum of skinfold is at zero percentile for different age groups. Table 8 shows range body fat is relation to age.

Table 1. Percentile scale for body fat percentage in relation to age

Percentile	Body fat percent							
	18 years	19 years	20 years	21 years	22 years	23 years	24 years	25 years
100	2	6	5	7	7	7	8	9
90	7	9	9	9	10	10	11	12
80	9	10	10	11	11	12	12	13
70	10	10	11	12	12	13	13	14
60	10	11	12	12	13	13	14	15
50	11	12	12	13	14	14	14	16
40	12	12	13	14	14	15	15	16
30	13	13	14	15	15	16	16	17
20	14	15	16	16	17	17	18	19
10	17	18	18	19	20	20	20	21
0	23	30	26	26	26	27	27	27

Table 2. Percentile scale for fat mass in relation to age

Percentile	Body fat percent							
	18 years	19 years	20 years	21 years	22 years	23 years	24 years	25 years
100	1	3	3	3	3	5	4	4
90	4	5	5	6	6	6	6	7
80	5	6	6	6	7	7	7	8
70	6	6	7	7	7	8	8	8
60	6	7	7	8	8	8	8	9
50	7	7	8	8	9	9	9	9
40	7	8	8	9	9	9	10	10
30	8	9	9	10	10	10	10	11
20	9	10	10	11	11	11	11	12
10	11	13	13	13	14	14	14	15
0	18	18	21	21	21	22	23	23

Table 3. Percentile scale for lean body mass in relation to age

Percentile	Body fat percent							
	18 years	19 years	20 years	21 years	22 years	23 years	24 years	25 years
100	68.2	75	70.1	67.7	66.7	71.7	71.2	70.2
90	60.3	61.6	62.2	61.9	61.1	60.9	61.1	60.3
80	58.7	58.5	60.5	60.3	59.1	59	59.2	58.3
70	57.2	57.5	58.1	57.6	57.1	56.6	56.4	55.8
60	55.4	56.4	57.5	57	56.2	55.7	55.5	55.1
50	54	54.8	56.1	55.9	55.2	54.4	54.2	53.8
40	53.3	54.2	54.1	54.1	53.7	52.8	52.6	51.9
30	52.7	53.4	52.6	52.7	52.4	51.5	51.3	50.7
20	51.3	52.4	50.7	51.3	51.2	49.5	49	48.7
10	49.8	50.1	49.3	49	48.9	46	46	45.5
0	44.4	39.6	42.6	43	35.2	41.6	35.1	34.6

Table 4. Percentile scale for chest skinfold in relation to age

Percentile	Body fat percent							
	18 years	19 years	20 years	21 years	22 years	23 years	24 years	25 years
100	2.2	4.2	4.8	5.2	5.8	6.2	6.2	6.6
90	5	6.4	6.8	7	7.4	7.4	7.4	8.2
80	6.2	7	7.8	8	8.2	8.4	8.6	9.4
70	6.8	7.4	8.2	8.6	8.6	9	9.2	10
60	7.4	7.8	8.8	9	9.2	9.6	9.8	10.6
50	8	8.4	9.2	9.6	9.8	10	10	11
40	8.6	9	9.6	10	10.6	10.8	11	11.8
30	9.4	9.8	10	11	11.4	11.6	12	12.6
20	10.2	10.8	11	12	12.4	12.4	13	13.4
10	12.6	14	14	14	15.8	15.4	16	16.2
0	23.4	24.4	26	26	25.8	26.8	27	27.4

Table 5. Percentile scale for triceps skinfold in relation to age

Per-centile	Body fat percent							
	18 years	19 years	20 years	21 years	22 years	23 years	24 years	25 years
100	3	3.2	4	4.4	5.6	5.2	5.4	6.2
90	6.8	8	8	8.2	8.6	9	9.2	9.8
80	8	8.6	9	9.2	9.6	10	10	11
70	8.8	9.2	9.8	10	10.4	10.8	11	11.8
60	9.4	10	10.6	11	11.2	11.6	12	12.6
50	10.2	10.8	11.4	12	12.2	12.4	13	13.4
40	11	11.6	12.2	12	12.8	13.2	13	14.2
30	11.8	12.8	13	13	13.8	14	14	15
20	13.2	14.4	14.4	15	15.4	15.6	16	16.6
10	15.4	16.8	17	17	18	18.2	18	19.2
0	22.6	24	24.2	25	24.8	25.4	26	26.4

Table 6. Percentile scale for sub scapular skin fold in relation to age

Per-centile	Body fat percent							
	18 years	19 years	20 years	21 years	22 years	23 years	24 years	25 years
100	1.8	3.4	4	5.6	6	5.8	5.8	7
90	8.8	8.8	8.6	8.8	9.2	9.6	9.6	10.8
80	10	9.6	9.8	10	11	11	11	11.8
70	10.6	10.6	10.8	11	12	12	12	12.8
60	11.4	11.2	11.6	12	13	13	13	13.8
50	12	12	12.4	13	13	14	14	14.6
40	12.8	12.8	13.2	14	14	15	14	15.4
30	13.6	13.6	14.4	15	15	16	16	16.4
20	14.8	15	15.8	16	16	17	17	17.8
10	16.4	17.4	17.8	18	18	19	19	20.2
0	23	24	27	24	24	25	26	26.4

Table 7. Percentile scale for sum of three skin fold in relation to age

Per-centile	Body fat percent							
	18 years	19 years	20 years	21 years	22 years	23 years	24 years	25 years
100	10.4	17.4	16.6	19	20.4	20.4	21	23.4
90	21	24.2	24.8	24.8	25.8	27	27	30
80	24.6	26.2	27.2	28.4	29	30.4	30	33
70	26.6	27.4	29.2	30.8	31.4	32.8	33	35.4
60	28.6	29.2	30.8	32.4	33.2	34.6	35	37.2
50	30.4	31	33	34.2	35.4	36.2	37	39.2
40	32.2	33	35	36.4	37.2	38.4	39	41.2
30	34.2	35.6	37	38.2	39.8	40.6	41	43.6
20	37.8	39.8	40.8	42	44	44.6	45	47.6
10	44.4	47.2	48.4	49.8	51.6	51.8	53	55.6
0	65.2	69.4	77.2	73.4	72.4	76	77	77.6

Table 8. Range of selected body composition components for college youth

Age in years	Body fat Percent	Fat mass
18	7.8–15.5	4.4–10
19	8.7–16	5–11
20	9.4–16.7	5.3–11.7
21	9.9–17.1	5.7–12
22	10.3–18	5.9–12.5
23	11–18.2	6.2–12.6
24	11.2–18.5	6.25–13
25	12.4–19.4	7–13.6

Note: The range for body composition components is ±SD from reported mean value

DISCUSSION

Percentile scales were prepared for different age groups for the college youth of Delhi State. The percentile scales provide a basis for interpreting an individual's score in terms of his standing in some specified group. However, percentile scale is not considered a standard scale as the mean and standard deviation are not used in constructing the scale and the scores are not distributed evenly.

Body composition may be influenced by a number of factors such as age, sex, diet, and exercise [7]. It was evident from the scales that various age groups considered in this study showed significant differences on body composition components. The difference existed may be due to combination of various factors. Vaccaro et al. [6] in their paper stated that aging is often associated with a gain in weight, an accumulation of body fat, a loss of lean tissue, demineralization of bone and decrement in aerobic power.

Increase in body fat percent showed a positive trend that lowest body fat percent as in 18 years age group, while the highest body fat percent was in 25 years age group. Increase in the body fat percent may be attributed to the improved living conditions of the subjects, which was clearly reflected in the increase in family income of the subject as the age increases. In the beginning of college years, physical activity level is higher but it tends to decrease a little with advancement of the age. Further this positive trend in body fat percent might be due the fact that in the early years of college life youths were generally inclined towards development of good physique but with maturity and in search for employment and career, they find little time for activity. This was also proved by the analysis of few motor fitness components.

Body fatness negatively influences performances both mechanically and metabolically in most physical tasks. Fat free weight on the other hand tends to have positive relation with physical performance. Body fat negatively influences performance involving agility, speed, endurance and jumping [2]. Further decreased lean body mass might be due to the decreased physical activity level and increased fat mass along with decreased performance in two motor fitness variables.

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