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ACUTE EFFECT OF STRENGTH EXERCISES WITH SUPERIMPOSED VIBRATION: IMPACT OF FREQUENCY AND AMPLITUDE OF OSCILLATIONS

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ABSTRACT

The aim of this study was to delineate the effect of different combinations of frequency and amplitude of superimposed vibration on attainment of maximal strength in exercises with isometric or isotonic concentric muscular contraction. The study was conducted on male trained adult volunteers ($n=8$, $\text{age}=33.5\pm3.8$). The athletes performed one arm pulling action without or with superimposed vibration that was transmitted from vibratory stimulation apparatus via cable and handle on the proximally located muscles of upper body. The exercises mode was isometric or isotonic concentric; in both cases the subjects developed maximal voluntary efforts. Vibration frequency varied between 17–38 Hz, and vibration amplitude between 2–8 mm. The ergogenic effect was evaluated as difference between force/power values attained in control and vibratory stimulated attempts. The findings display significant stimulatory effect of superimposed vibration in isotonic concentric exercise (increase varied between 8.8–38.3%) and, in much lesser extent, in isometric drill (increase varied between 1.7–5.8%). In isotonic exercise increase of vibration frequency and amplitude within the range of 17–38 Hz and 2–8 mm

produced gradual elevation of motor output, whereas in isometric exercise only the proper combinations of frequency and amplitude provided appropriate intensity of mechanical signal, which determined maximal stimulatory effect.

Key words: vibration training, muscular strength, isometric and isotonic contraction.

INTRODUCTION

Strength practice incorporating vibration has become especially popular and widely used over the last decade both in high-performance sport and health-related training [2, 8, 12, 23]. The application of vibration in physical training embraces two principal approaches: (1) physical exercises with local vibration (LV), when the superimposed vibration is transmitted to contract or stretched muscles, and (2) motor tasks performed while the whole body is being vibrated. Therapeutic procedures utilizing LV have been exploited in physiotherapy and clinics since the 19th century, but recent interest and extensive research were stimulated by the findings of Eklund and Hagbarth [9] studying the phenomenon of vibratory induced non-voluntary contraction, and introducing the term *Tonic Vibration Reflex* (TVR). The ergogenic impact of superimposed LV was studied in terms of acute and cumulative effects of vibration training. In both cases parameters of superimposed vibration, such as frequency and amplitude of regular oscillations, were of special interest. The spectrum of frequencies and amplitudes, which were employed, varied substantially (for review, see Issurin [12]), and various combinations have been selected empirically or following general theoretical prerequisites [18, 21].

The acute ergogenic effect of superimposed LV was studied using various models of physical exercises. Some examined these effects on isometric exercises [6, 11, 28, 29], whereas the others studied isotonic dynamic contractions [5, 14, 25, 29]. The reported outcomes varied widely, however attained ergogenic effect of LV was eventually larger in dynamic exercises. This difference of attained benefits seems worthy for special investigation. Moreover, it is assumed that the most favorable combinations of the LV frequency and amplitude parameters can vary for isometric or isotonic exercises. The purpose

of this study is to delineate the effect of different combinations of frequency and amplitude of superimposed vibration on attainment of maximal strength in exercises with isometric or isotonic concentric muscular contraction.

MATERIALS AND METHODS

Subjects

Eight male trained athletes, former experienced kayakers (age=33.5±3.8 years; height=177±4cm, weight=75.5±3.5kg) volunteered to participate in this study. All participants were accustomed to strength exercises and were very familiar with vibration training. They passed preliminary session where they got familiarized with the intended exercises, equipment, and procedures. Due to their experience in testing exercise and sufficient fitness level, the athletes were able to provide high reproducibility in obtaining maximal effort both in isometric and isotonic exercises. They have signed informed consent before beginning the study.

Apparatus

The athletes performed one arm pulling action in sitting position similarly to a kayak stroke (see Figure 1). They were positioned on a special seat with support for two legs; the soft pad was fixed behind the subject on the neck level to prevent body extension during effort. The athletes performed a pulling action by the dominant arm involving upper body muscles and trunk rotation identically to a kayak paddle stroke. During isomeric exercise the cable was anchored to a wall; pulling began by positioning straight arm placed 70° to trunk axis; preliminary measurements revealed that this angular position allows obtaining maximal force values. During the isotonic exercise the cable was connected to a hydraulic training machine "Champion"; pulling was initiated by positioning straight arm with maximally stretched upper body muscles from preliminary rotated trunk position, similarly to a kayak stroke performance, and ending when the hand reached vertical axis of the hip joint. The external resistance of the hydraulic training machine was settled on the force level that corresponded to 300–500 Newton; the force value depended on the pulling velocity.

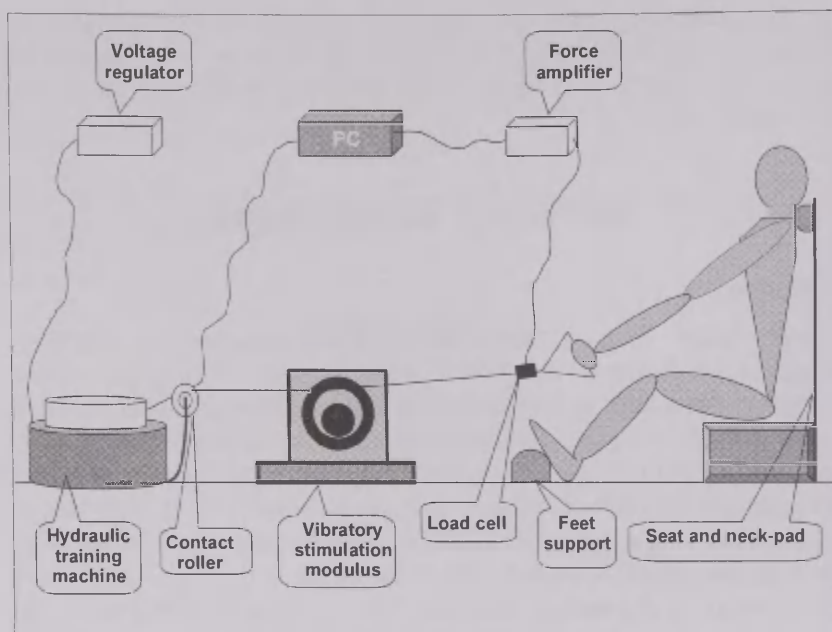


Figure 1. Experimental setup for isotonic concentric exercise; in isometric exercise the cable was anchored to a wall.

The superimposed vibration was produced by a specially designed vibratory stimulation device [13], which contains a three kilowatt 3-phase electromotor with a speed reduction and regulation; eccentric wheel with changeable eccentricity; cable that passed through eccentric wheel via the pulleys, with the arm handle on the edge. Vibration frequency was settled by means of input of appropriate voltage on the electromotor; correspondingly 17, 27 or 38 Hz were programmed. Regulation of vibration amplitude was achieved by alteration of the wheel eccentricity, and was equal to 2, 4 or 8 mm following the protocol of study. The average calculated vibratory acceleration varied between 7.7–160 m/s^2 depending on the proper combination of vibration's frequency and amplitude.

The force values were obtained by measurement of the cable tension via load cell (model TR, BM-Cybernetics); the generated signal was transmitted to force amplifier (Topaz-4, St-Petersburg) and PC. The pulling velocity in dynamic exercise was measured by means

of contact roller, where rotations generated proportional signal; the mean power of each single pull was automatically computed and transmitted to a PC.

Design and procedure

The study lasted two days. Each day program included general warm-up for 5–7 min, and task-specific warm-up using the experimental equipment. Participants practiced the exercise employing sub-maximal and maximal modes of effort using 10–12 repetitions. At each day the athletes performed three consecutive series of exercises with LV amplitude of vibration set at 2, 4, and 8mm, respectively. Such sequencing was selected to prevent premature accommodation to vibration excitation of maximal intensity. Therefore, each series contained four attempts, where the first one was always performed without vibration and served for control of basic level, and for monitoring of fatigue during the entire working day. The rest three attempts of each series were performed with LV frequencies set at 17, 27 and 38Hz and practiced in random order. Each attempt included two maximal effort repetitions with an interval of 5–8s; the maximal value was taken for further calculations. The interval between succeeding attempts was set at 2–3 min until the subject was completely ready for next effort. The rest interval between each series lasted 12–15min; the level of fatigue of efforts was controlled by comparison of the force/power values in attempts without vibration in each series; reproducibility level was maintained within interval and reached 1.5%.

The testing procedure both in isometric and isotonic exercises presupposed positioning of the athlete on the seat keeping the handle in dominant arm with preliminary tensioned cable. Vibration device was switched on for 1.5–2s prior the command “Start”. The athletes were asked to develop maximal voluntary contraction immediately after the command as fast as possible. In isometric exercise the athlete maintained maximal effort until command “Stop” during 5 seconds. The second repetition was performed identically after a 5–8s interval. In isotonic exercises the athlete pulled the cable with maximal velocity until the hip joint; pulling time varied in range between 1.2–1.5 s. Afterwards the training machine returned the cable back, and the athlete performed second repetition within the same time interval (e.g., 5–8s).

The registered variables taken for further analysis were the following: isometric exercises – maximal peak force; isotonic exercises – mean power of pulling action. The differences between no- vibration condition and each combination of amplitude and frequency of vibration were computed for each athlete, and were expressed in percent.

Data analysis

As each participant was exposed to 9 treatments comprising of a combination of 3 levels of LV frequency (i.e., 17, 27 and 38 Hz) and 3 levels of amplitude (i.e., 2, 4, and 8mm), a repeated measures within subjects (RM-WS) analysis of variance (ANOVA) was employed separately for the dynamic and isometric data sets (i.e., % change from control condition). Sphericity assumptions were tested prior to inferential procedures implementations, followed by appropriate adjustment procedures. Descriptive statistics (mean, SD) were computed to illustrate the significant effect in graphical modes. Significance level was adjusted according to Boneffroni procedure

RESULTS

Dynamic data set

Despite the relative small sample size ($n=8$), Mauchly's test of Sphericity has failed to show any violation for both frequency and amplitude effects (Mauchly's W 's=0.88 and 0.51, $p>0.05$, respectively). However the sphericity assumption of the frequency by amplitude interaction was violated (Mauchly's $W=0.003$, $p=0.001$). Thus, for the main effects, Wilks' λ multivariate tests were employed, while for their interaction Greenhouse-Geisser (GG – no sphericity assumed) within subject effect was used with adjusted degrees of freedom.

Both frequency and amplitude of LV resulted in significant effects on power gain, Wilks' $\lambda=0.008$, $F(2,6)=368.99$, $p<0.001$, $\eta^2=0.992$, and Wilks' $\lambda=0.014$, $F(2,6)=211.13$, $p<0.001$, $\eta^2=0.986$, respectively. These effects are shown in Figure 2a,b. Pertaining to LV frequency, power gain increased by 13.60%, 19.03%, and 25.67% following practices with LV frequencies of 17Hz, 27Hz, and 38Hz, respectively. With respect to LV magnitude, percent increase in dynamic power

associated with 2mm, 4mm, and 8mm was 12.07%, 20.10%, and 25.63%, respectively.

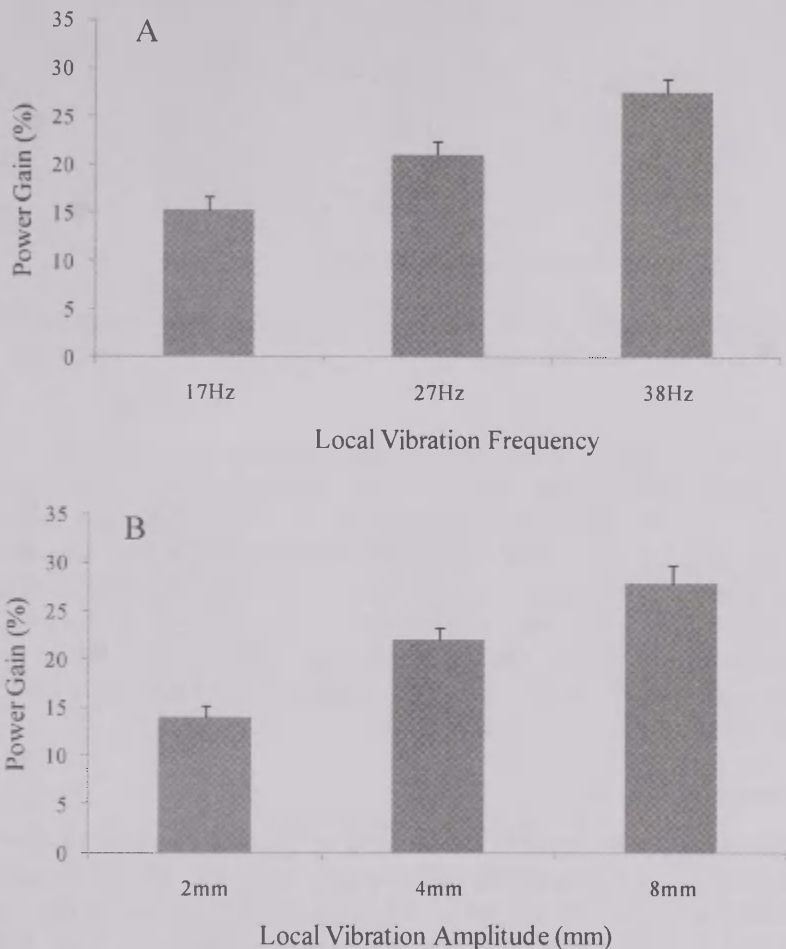


Figure 2. Means and SDs for power gains with respect to (A) 3 levels of LV frequency (17, 27, and 38 Hz), and (B) 3 levels of LV amplitude (2, 4, and 8 mm)

The frequency by amplitude interaction resulted in a significant effect on dynamic power gain, $GG=536.23$, $F(1.84, 12.70)=82.67$, $p<0.001$, $\eta^2=0.92$, and is presented in Figure 3.

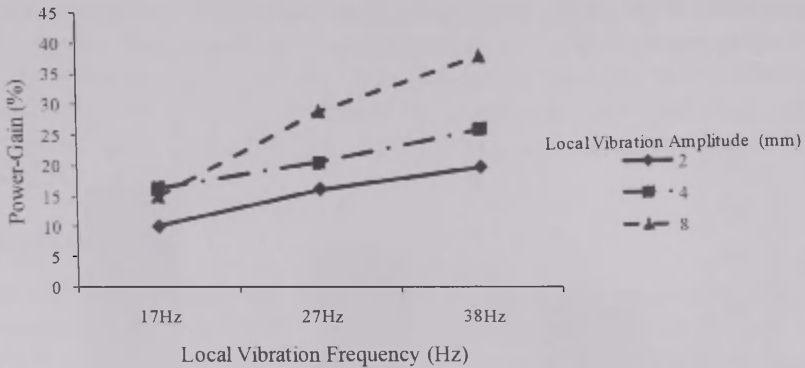


Figure 3. Dynamic power gain means for the 9 interventions comprised of frequency and amplitude of LV.

The results show a monotonic and sharp increase in power gain as LV frequency and amplitude increase simultaneously. Under 8mm amplitude, dynamic power increased by 15.14%, 29.34% and 38.33% following 17Hz, 27Hz, and 38Hz, respectively. While less than 4mm amplitude the increase in power associated with frequency increase was 16.81%, 20.56%, and 25.94%, respectively. A somewhat moderate increase in dynamic power was noticed when practice was carried out with 2mm amplitude, resulting in an increase of 9.88%, 16.39%, and 19.67%, respectively.

Isometric data set

Mauchly's test of Sphericity has failed to show any violation for both frequency and amplitude effects, as well as their interaction (Mauchly's W 's = 0.90, 0.48, and 0.22, $p > 0.05$, respectively), thus Wilks' λ multivariate tests were employed to these 3 effects. Both main effects for frequency and amplitude of LV reached significance, Wilks' $\lambda = 0.05$, $F(2,6) = 353.21$, $p < 0.001$, $\eta^2 = 0.95$, and Wilks' $\lambda = 0.08$, $F(2,6) = 36.36$, $p < 0.001$, $\eta^2 = 0.92$, respectively. These effects are shown in Figure 4a,b.

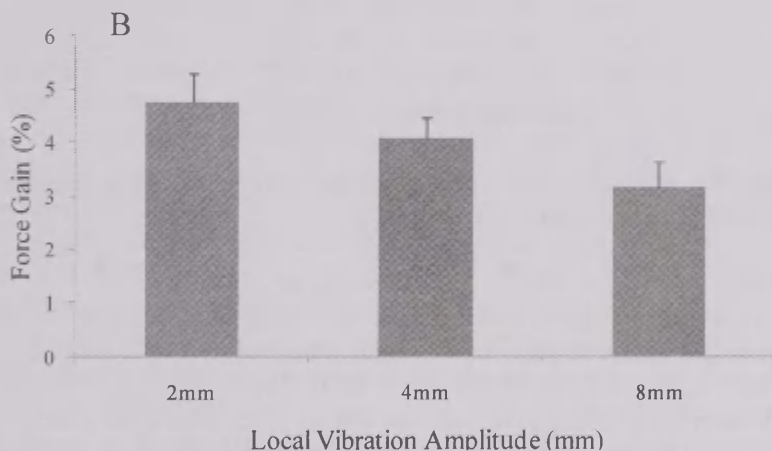
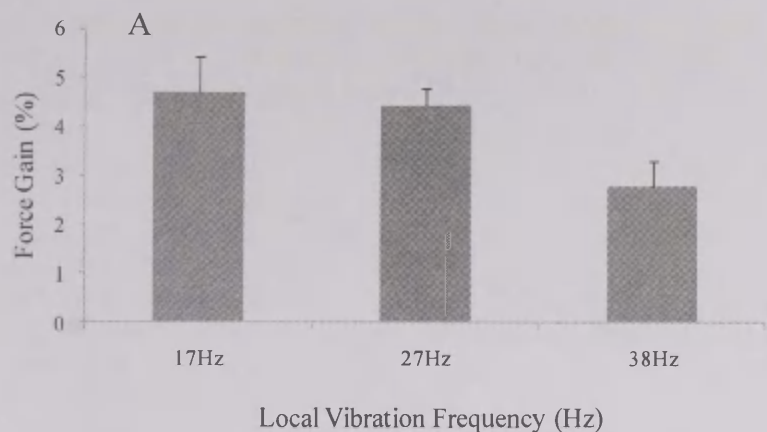


Figure 4. Means and SDs for force gain with respect to (A) 3 levels of LV frequency (17, 27, and 38 Hz), and (B) 3 levels of LV amplitude (2, 4, and 8 mm)

The frequency effect resulted from a monotonic decrease in force gain as LV frequency increase: 3.57%, 3.83%, and 1.67% associated with frequency of 17Hz, 27HZ, and 38Hz, respectively. Similar decrease was associated with increase in LV amplitude from 2mm, through 4mm, to 8mm: 4.07%, 3.40%, and 2.13%, respectively.

The frequency by amplitude LV interaction effect on force using the multivariate test reached significance, Wilks' $\lambda=0.01$, $F(4,4)=89.05$, $p<0.001$, $\eta^2=0.99$, and is presented in Figure 5.

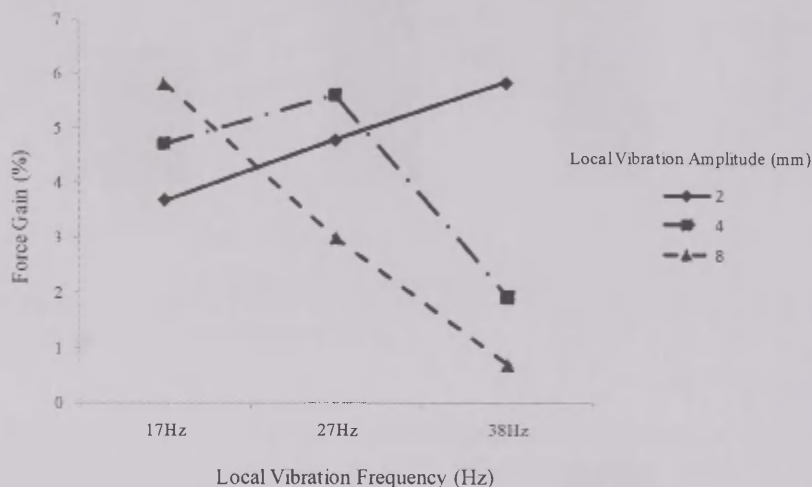


Figure 5. Isometric force changes for the 9 interventions comprised of frequency and amplitude of LV.

As noticed in Figure 5, increases in LV frequency resulted in sharp decreases in force gain under 8mm amplitude: 5.80% with 17Hz, 2.98% with 27Hz, and 0.68% with 38Hz. When practiced with 4mm LV amplitude, force gain was the lowest when practiced with 38Hz LV (1.90%), and increased with LV frequencies of 27Hz and 17Hz (5.80% and 4.71%, respectively). Finally, when amplitude of LV was 2mm, monotonic increase in force gains were obtained with frequency increase from 17Hz thorough 27Hz to 38Hz: 3.68%, 4.76%, and 5.80%, respectively.

DISCUSSION

The different magnitude of ergogenic effect elicited by LV in isometric and isotonic exercises has been reported and considered in a number of previous publications. Several studies employing LV in

isometric exercises failed to obtain any acute effect on maximal force attainment [4, 11, 29], whereas others reported moderate, but significant, gain in maximal force [6, 7, 28], and pronounced increase of EMG activation [22]. Unlike the studies employing isometric contractions accompanied with LV, the effects of isotonic exercising with LV resulted in substantial gains on maximal force and/or power [14, 17, 25, 29]. Thus, it seems that exercising with LV produces greater ergogenic effect while applied to dynamic than to isometric muscular contraction. Findings of the current study support this supposition. Moreover, the magnitude of power gain (38%) in the present study substantially exceeded the gains' values ranging from 4.8–26.4% obtained in previous studies [5, 14, 17, 25].

The marked stimulatory effects of LV on isometric and isotonic muscular contractions is attributed to neural and biomechanical factors. The underlying neural mechanism of vibratory stimulation presupposes that vibration causes excitation of primary afferent endings of motor spindles, and recruitment of muscular receptors, which activate a larger fraction of α -motoneurons whose discharges recruit previously inactive muscle fibers into contraction. The exercises employing LV in the current study provided vibration transmission via cable and handle to a distal link with further propagation of vibratory wave through big mass of proximally located muscles. This caused severe activation of vibratory sensitive muscle receptors, and recruitment of many additional motor units into contraction. This proposed mechanism can be relevant both for isometric and isotonic contractions; however a number of specific circumstances cause the marked difference, which can be more beneficial to motor response in dynamic exercises. More specifically, unlike isometric exercise, the isotonic drill initiated a pre-stretched position and preliminary acted vibration, which elicited the active state prior to contraction. In these conditions the stretch reflex largely contributes to the force development [16].

It is known that force enhancement in Stretch-Shortening Cycle (SSC) exercises is strongly affected by reflexive facilitation of efferent caused by Ia afferents [27]. Likewise, isotonic concentric exercises being preliminary affected by superimposed vibration benefit from Ia afferent inflow, which produce excitatory effect on the α -motoneurons [3, 4, 20]. Therefore, it is maintained that superimposed vibration facilitates stretch reflex, which in turn produces a decisive impact on force and power generation in dynamic exercises.

One more suggestion is concerned with difficulty in activation of large muscle groups in dynamic voluntary contraction [15]. In our study vibratory stimulation was administered prior to the muscular contraction, and this pre-activation could result in a facilitatory effect on subsequent voluntary effort.

Additional factor determining ergogenic effect of LV in isometric and isotonic exercises is the initial length of the muscles prior contraction. Three decades ago, Bishop (1974) found that preliminary lengthened muscles were more sensitive to vibration, and contract more strongly. Both in industrial activities [26] and physical exercises [12] increased muscles length provided higher motor output. In our study the isotonic exercise was initiated by straight-arm with maximally stretched upper body muscles, whereas the isometric pulling action started from arm position set at 70° to trunk axis; correspondingly, the initial muscles length was greater prior to dynamic than isometric efforts. Therefore, such factors like higher stretch-sensitivity, facilitated pre-activation and increased muscle length largely contribute into pronounced ergogenic effect produced by LV in dynamically contracted muscles as compared with isometric contraction.

LV frequency was found to evoke a proportional increase in muscle tension [19]; a finding confirmed in the present study with isotonic concentric contraction, whereas the isometric contraction gained maximal stimulatory effect under specific conditions unrelated to maximal intensity of mechanical signal. The marked difference in motor output between isotonic and isometric contraction needs special consideration. It should be noted that the most integrative indication of the vibration's intensity can be given by considering vibratory acceleration as a function of the frequency and amplitude in mechanical signal [10]. Figure 5 displays those different combinations of frequency and amplitude i.e. 2 mm-38 Hz, 4mm-27Hz, and 8mm-17 Hz, which elicited maximal and almost the same gain of isometric force. Importantly, these three combinations are characterized by similar average vibratory acceleration ranged within $32\text{--}40 \text{ m/s}^2$. The lower and higher magnitudes of vibration's intensity produced lower ergogenic effect. Thus, it can be suggested that stimulatory effect has reached a critical intensity of mechanical signal from which any further increase results in a suppressive response. Such inhibition can be associated with aggravated activation of Golgi tendon organs. Indeed, when the muscle contracts isometrically, it develops tension,

and the in-series-attached Golgi tendon organ increases its discharge [16, 24]. Presumably the severe vibration signal (up to 160 m/s^2 of average vibratory acceleration) exceeds reserves of the force receptors' accommodation and Golgi tendon reflex evokes inhibition of motor output.

In summary, the current findings display apparent stimulatory effect of superimposed LV on isotonic concentric power and, in much lesser extent, on isometric strength. However increase of the frequency and amplitude of LV within the range 17–38 Hz and 2–8 mm produces very different ergogenic impacts. In isotonic exercise this increase elicited gradual elevation of motor output, whereas in isometric exercise the proper combinations of frequency and amplitude provide certain intensity of mechanical signal, which determines maximal stimulatory effect of LV.

CONCLUSION

Exercising incorporating vibratory stimulation belong to the branch of new sport technologies that draw much attention in both practitioners and researchers. The sport industry produces various devices and training machines, which facilitate the implementation of vibratory exercises into the practice. Thus, determination of the most efficient training regimes has apparent scientific and practical importance. The outcomes of the present study can be reasonably adapted in three following directions: (1) dynamic concentric exercises with superimposed vibration have much higher ergogenic effect on maximum strength abilities than similar exercises with isometric muscular contraction; (2) more pronounced stimulatory effect of superimposed vibration in dynamic exercises demands higher intensity of mechanical signal, which is provided by higher frequency and larger amplitude of oscillations; in the present study the most beneficial regime was obtained with frequency 38 Hz and amplitude 8 mm, (3) in the isometric vibratory exercises the maximal stimulatory effect is conditioned by lower intensity of mechanical signal (i.e. 38 Hz and 2 mm; 27 Hz and 4 mm; and 17 Hz and 8 mm of frequency and amplitude respectively). These data can be utilized for planning similar studies using vibratory stimulation incorporated with exercising under various training modalities.

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THE EFFECT OF AGE ON RELATIONSHIPS BETWEEN PERCEIVED TEACHING BEHAVIOURS, BASIC PSYCHOLOGICAL NEEDS AND SELF-DETERMINED MOTIVATION IN PHYSICAL EDUCATION

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ABSTRACT

The present study examined the effect of age on relationships between perceptions of various teaching behaviours, satisfaction of the basic psychological needs for competence, autonomy, and relatedness, and self-determined motivation in physical education, using Deci and Ryan's self-determination theory [3] as a theoretical framework. The 264 students from 7th grade (M age=13.2, SD=0.42) and 432 from 12th grade (M age=18.1, SD=0.38) completed measures of perceived teaching behaviours with dimensions of democratic behaviour, autocratic behaviour, teaching and instruction, situation consideration, positive general verbal feedback, and both positive and negative nonverbal feedback, as well as measures of perceived satisfaction of the needs for competence, autonomy, and relatedness, and self-determined motivation. Path-analytic models revealed similarities and discrepancies in the magnitude of relationships between perceived teaching behaviours, satisfaction of the basic psychological needs, and self-determined motivation in physical education among students with different age groups. Results suggested that for 7th graders, the perception of positive general verbal feedback was essential antecedent of self-determined motivation, whereas for 12th graders both perceptions of positive general verbal feedback and democratic behaviour were essential antecedents of self-determined motivation in physical education.

Key words: significant other, 7th and 12th grade students, intrinsic and extrinsic motivation, path analysis

INTRODUCTION

One of the most influential factors affecting students' motivation in physical education (PE) is teacher's behaviour. For example, in line with self-determination theory (SDT) [3], Standage and colleagues [12] demonstrated that secondary school students' perceptions of teacher's generic autonomy support positively predicted self-determined motivation through the satisfaction of the basic psychological needs for competence, autonomy, and relatedness. Koka and Hagger [7], however, tested the process by which perceptions of various specific teaching behaviours such as democratic behaviour versus autocratic behaviour, teaching and instruction, situation consideration, and both verbal and nonverbal feedback influence students' self-determined motivation in PE, using SDT as a framework. They found that only perceived positive general verbal feedback had a significant indirect effect on students' self-determined motivation in PE via the satisfaction of needs for competence and relatedness. Unexpectedly, results revealed that perceived situation consideration, and teaching and instruction had significant positive and direct effects, whereas autocratic behaviour, and negative nonverbal feedback had negative and direct effects on students' self-determined motivation in PE, unmediated by the psychological needs satisfaction variables as hypothesised by SDT. Koka and Hagger [7] explained this deviation from the tenets of SDT by suggesting that these teaching behaviours failed to provide students with the substantial competence information or facilitate their feelings of autonomy and relatedness in PE.

Studies have showed that students of different ages differ in preferred and perceived instructional/teaching behaviours [2, 6]. Koka [6], for example, demonstrated that 12th graders scored significantly higher than 7th graders on several perceived teaching behaviours such as teaching and instruction, social support, situation consideration, and informational feedback, but lower on autocratic behaviour and negative nonverbal feedback. While age differences in mean scores of perceived teaching behaviours as well as basic psychological needs and self-determined motivation have been determined, the pattern of relationships between these variables in PE among students with

different age groups have not yet established. The present study thus aimed to test the process by which perceptions of various teaching behaviours such as democratic behaviour and autocratic behaviour, teaching and instruction, situation consideration, and both verbal and nonverbal feedback influence students' self-determined motivation in PE among students with different age groups, using SDT [3] as a theoretical framework.

METHODS

Participants and procedures

Participants were 696 students from several schools located in southeast of Estonia. From the sample, 264 students were in 7th grade (M age=13.2, SD=0.42) and 432 were in 12th grade (M age=18.1, SD=0.38). In all schools only those classes were included to the study where the same PE teacher was teaching both 7th and 12th grade students. Permission to carry out the study was obtained from the headmaster or from a class teacher. Also, parental consent was obtained for all children. Questionnaires were administered in quiet classroom conditions. The questionnaire took approximately 15 min to complete. Students were assured that their answers would remain confidential.

Measures

The Leadership Scale for Physical Education [7] was used to assess students' perceptions of various teaching behaviours in PE with dimensions of democratic behaviour, autocratic behaviour, teaching and instruction, and situation consideration. The Perceptions of the Teacher's Feedback questionnaire [8] was used to assess students' perceptions of different types of teacher's feedback in PE on dimensions of positive general verbal feedback, positive nonverbal feedback, and negative nonverbal feedback.

Students' perception of competence in PE was measured by the subscale from the Intrinsic Motivation Inventory [9]. Students' perception of autonomy in PE was measured using a 3-item scale [7]. Students' perception of relatedness in PE was assessed using five items derived from the previous research in sport setting [4] that has been modified to the PE context by Koka and Hagger [7].

An adapted version of the Behavioural Regulations in Exercise Questionnaire [10] was used to assess students' intrinsic motivation, identified regulation, introjected regulation, and external regulation in PE. To estimate relations among study variables in the path model, four types of motivation were integrated into single index of autonomous motivation by calculating a self-determined index, also called as self-determined motivation. That is, each subscale average score were weighted as following: intrinsic motivation (+2), identified regulation (+1), introjected regulation (-1), and extrinsic regulation (-2), and a self-determined index was calculated based on the weighted composite of these scores.

Data analyses

First, Independent-samples T-tests were used to investigate age differences on all variables. Second, separate path analysis for 7th graders and 12th graders with averaged manifest scales for each construct was carried out to test relationships between study variables, using structural equation modelling package named LISREL 8.51. The path analysis was carried out in two steps. The first step included the specification of the model in which various dimensions of perceived teaching behaviours were hypothesized to predict students' self-determined motivation only through the satisfaction of psychological needs for competence, autonomy, and relatedness. The second step included the specification of the model in which all dimensions of perceived teaching behaviours were hypothesized to predict students' self-determined motivation directly. This was done to demonstrate whether the effects of perceived teaching behaviours are completely or partially mediated by the psychological needs.

Several indices such as Comparative Fit Index (CFI), Non-Normed Fit Index (NNFI), and Root Mean Square Error of Approximation (RMSEA) were used to assess the adequacy of the fit of path models to the data. According to Hu and Bentler [5], a model that fits the data well is indicated when values for CFI and NNFI are close to or greater than .95, and values for RMSEA is .06 or less.

RESULTS

Preliminary analysis

Results of the Independent-samples T-tests indicated that 7th graders scored significantly higher than 12th graders on perceived teaching and instruction behaviour and negative nonverbal teacher's feedback, but lower on both perceptions of autonomy and relatedness in PE (see Table 1).

Table 1. Age differences for all study variables.

	7 th Graders (n=264)		12 th Graders (n=432)		
	M	SD	M	SD	t-value
Democratic behaviour	2.86	0.84	2.90	0.84	0.54
Autocratic behaviour	2.27	0.81	2.16	0.76	1.82
Teaching and Instruction	3.49	0.77	3.37	0.77	1.98*
Situation consideration	3.36	0.84	3.47	0.93	1.59
Positive general feedback	3.25	0.96	3.22	0.93	0.39
Positive nonverbal feedback	2.58	0.87	2.54	0.92	0.44
Negative nonverbal feedback	2.06	0.87	1.72	0.74	5.23***
Perceived competence	3.78	0.87	3.80	0.87	0.23
Perceived autonomy	2.71	1.05	2.87	0.98	2.00*
Perceived relatedness	4.67	1.46	5.02	1.24	3.24***
Self-determined motivation	4.58	3.50	4.73	3.33	0.55

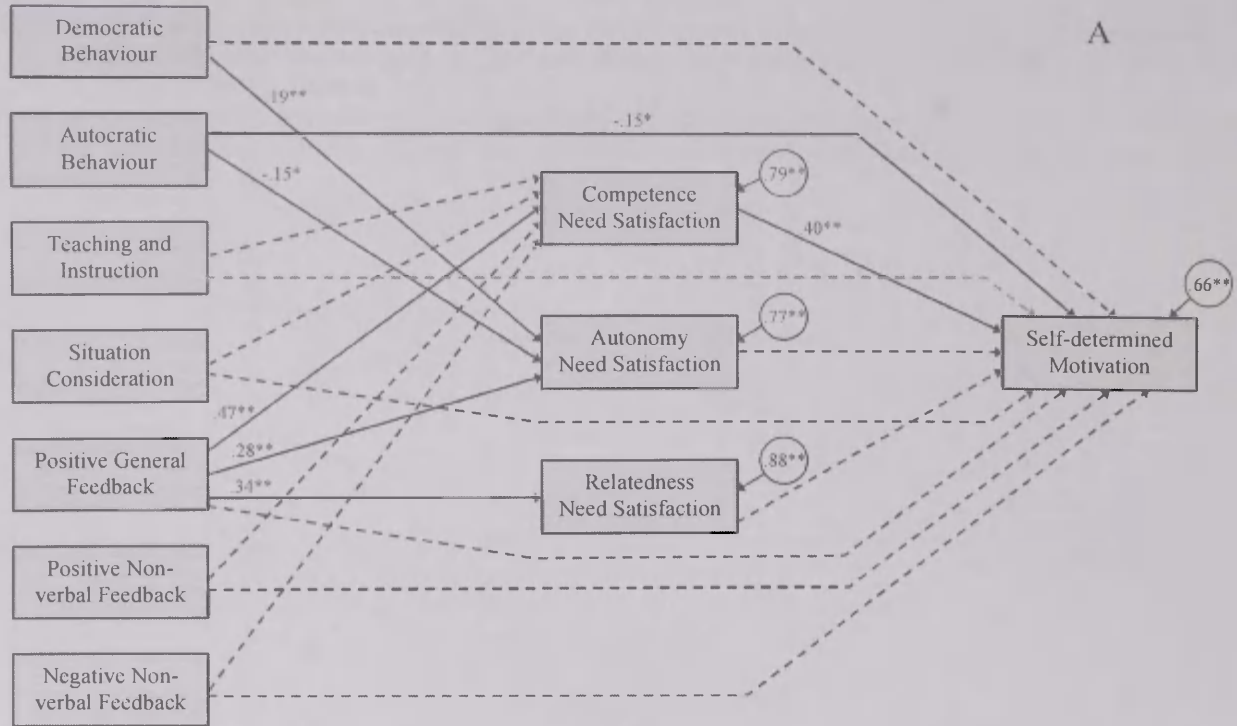
Note. All variables were measured on 5-point scale, with the exception of the Perceived relatedness variable, which was measured on 7-point scale. * $p < 0.05$; *** $p < 0.001$.

Main analysis

The path models in which various dimensions of perceived teaching behaviours were hypothesized to predict students' self-determined motivation through the satisfaction of psychological needs for competence, autonomy, and relatedness exhibited poor fit with the data for both 7th graders and 12th graders (Path model for 7th graders: Satorra-Bentler $\chi^2(19)=60.75$, $p < 0.001$, CFI=0.95, NNFI=0.85, RMSEA=0.093, 90% confidence interval (CI₉₀) for RMSEA range=0.067 to 0.120; Path model for 12th graders: Satorra-Bentler

$\chi^2(19)=91.59$, $p<0.001$, $CFI=0.96$, $NNFI=0.88$, $RMSEA=0.095$, CI_{90} for $RMSEA$ range=0.076 to 0.110). Therefore, alternative models for both 7th graders and 12th graders were tested in which direct paths from all dimensions of perceived teaching behaviours on self-determined motivation were specified as free parameters. The alternative models exhibited good fit with the data for both 7th graders and 12th graders (Path model for 7th graders: Satorra-Bentler $\chi^2(12)=22.38$, $p=0.034$, $CFI=0.99$, $NNFI=0.94$, $RMSEA=0.058$, CI_{90} for $RMSEA$ range=0.016 to 0.095; Path model for 12th graders: Satorra-Bentler $\chi^2(12)=33.58$, $p<0.001$, $CFI=0.99$, $NNFI=0.94$, $RMSEA=0.065$, CI_{90} for $RMSEA$ range=0.040 to 0.092). The standardized path coefficients for the free parameters in the alternative models for both 7th graders and 12th graders are presented in Figure 1. For 7th graders, the model accounted for 34% of the variance in self-determined motivation and 21%, 23%, and 12% of the variance in perceived competence, autonomy, and relatedness, respectively. For 12th graders, the model accounted for 36% of the variance in self-determined motivation and 19%, 32%, and 9% of the variance in perceived competence, autonomy, and relatedness, respectively.

For 7th graders, results of the path analysis indicated that only perceived competence ($\beta=0.40$, $t=6.24$, $p<0.01$) had significant positive effect on students' self-determined motivation in PE. Perception of autonomy was positively predicted by perceived democratic behaviour ($\beta=0.19$, $t=2.94$, $p<0.01$), but negatively by perceived autocratic behaviour ($\beta=-0.15$, $t=-2.46$, $p<0.05$). However, the indirect effects of both perceived democratic and autocratic behaviour on self-determined motivation were not significant. Perception of autocratic behaviour ($\beta=-0.15$, $t=-2.39$, $p<0.05$) had also significant negative and direct effect on self-determined motivation. Significant positive effect of perceived positive general feedback on the perceived competence ($\beta=0.47$, $t=5.48$, $p<0.01$), autonomy ($\beta=0.28$, $t=4.45$, $p<0.01$), and relatedness ($\beta=0.34$, $t=5.78$, $p<0.01$) emerged. Moreover, the indirect effect of perceived positive general feedback ($\beta=0.17$, $t=3.77$, $p<0.01$) on self-determined motivation through the perceived competence was significant.



(Figure continues)

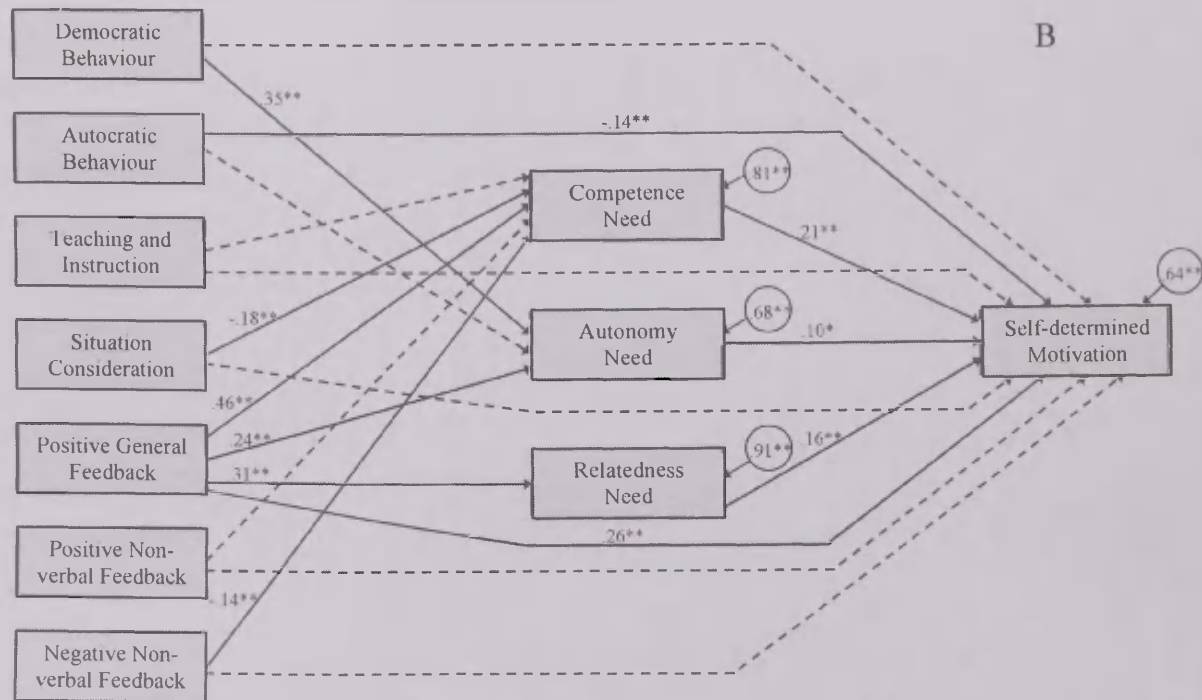


Figure 1. Path analysis showing relations between perceived teaching behaviours, perceived satisfaction of the needs for competence, autonomy, and relatedness, and self-determined motivation in physical education (A) for 7th graders and (B) for 12th graders.

Note. All path coefficients are standardized. The feint broken lines indicate non-significant paths. For clarity, error covariances among perceived competence, autonomy, and relatedness need satisfaction variables are omitted. Covariances of the error terms for 7th graders were as follows: $r_{\text{competence-autonomy}}=0.07$, $r_{\text{autonomy-relatedness}}=0.23$, $r_{\text{competence-relatedness}}=0.18$. Covariances of the error terms for 12th graders were as follows: $r_{\text{competence-autonomy}}=0.13$, $r_{\text{autonomy-relatedness}}=0.16$, $r_{\text{competence-relatedness}}=0.17$. * $p<0.05$; ** $p<0.01$.

For 12th graders, results of the path analysis indicated that both perceived competence ($\beta=0.21$, $t=4.55$, $p<0.01$), autonomy ($\beta=0.10$, $t=2.01$, $p<0.05$), and relatedness ($\beta=0.16$, $t=3.83$, $p<0.01$) had significant positive effects on students' self-determined motivation in PE. Similarly with 7th graders, significant positive effects of perceived positive general feedback on the perceived competence ($\beta=0.46$, $t=5.84$, $p<0.01$), autonomy ($\beta=0.24$, $t=4.83$, $p<0.01$), and relatedness ($\beta=0.31$, $t=6.57$, $p<0.01$) emerged. The indirect effect of perceived positive general feedback ($\beta=0.17$, $t=5.51$, $p<0.01$) on self-determined motivation was significant through the all three psychological needs. However, perceived positive general feedback predicted students' self-determined motivation also directly indicated that three psychological needs only partially mediated the effect of perceived positive general feedback on self-determined motivation. Perception of autonomy was positively predicted by perceived democratic behaviour ($\beta=0.35$, $t=6.34$, $p<0.01$). Furthermore, the indirect effect of perceived democratic behaviour ($\beta=0.04$, $t=2.02$, $p<0.05$) on self-determined motivation was significant. Perception of competence was negatively predicted by negative nonverbal feedback ($\beta=-0.14$, $t=-2.84$, $p<0.01$) and situation consideration ($\beta=-0.18$, $t=-2.83$, $p<0.05$). The indirect effect of negative nonverbal feedback ($\beta=-0.03$, $t=-2.33$, $p<0.05$) on self-determined motivation was also significant. Finally, the indirect effect of perceived situation consideration on self-determined motivation was small and borderline in statistical significance ($\beta=-0.03$, $t=-1.96$, $p=0.05$).

DISCUSSION

The present study revealed some similarities and discrepancies in the magnitude of relationships between perceived teaching behaviours, satisfaction of the basic psychological needs for competence, autonomy, and relatedness, and self-determined motivation in PE among students with different age groups. First, results indicated that while satisfying the all three psychological needs for competence, autonomy, and relatedness were related to 12th graders self-determined motivation in PE, only satisfying the need for competence was related to 7th graders self-determined motivation. This is not surprising, as 12th graders perceived significantly higher than 7th graders that their

feelings of autonomy and relatedness in PE were satisfied (see Table 1). These results suggest that 7th graders are not included into the decision-making process by their PE teachers as much as their older counterparts that would facilitate the feelings of autonomy. It is also possible, as noted by Ntoumanis [11] and later by Koka and Hagger [7], that teachers are probably not very skilled in using autonomy supportive instructional behaviours. Significantly lower score in perceived relatedness among 7th graders seems to indicate that close relationships among classmates have not been developed yet that would facilitate the feelings of belonging.

Turning next to the SDT [3] hypothesis that satisfying basic psychological needs would mediate the effects of various perceived teaching behaviours on students' self-determined motivation in PE, results of path-analytic models revealed that the mechanism of how perceived teaching behaviours affect self-determined motivation might vary among students with different age groups. For 7th graders, the pattern of relationship proposed by SDT was evident only for perceived positive general verbal feedback. This is consistent with results of previous study with students of similar ages [7]. For 12th graders, however, the pattern of relationship proposed by SDT was supported for perceived teaching behaviours such as positive general verbal feedback, democratic behaviour, nonverbal negative feedback, and situation consideration with positive general verbal feedback and democratic behaviour having positive, but nonverbal negative feedback and situation consideration having negative indirect effect on self-determined motivation. The negative indirect effect of negative nonverbal feedback and positive indirect effect of positive general verbal feedback and democratic behaviour was expected. That is, the more students felt that their teachers provided them with positive feedback (i.e., praise and encouragement) and included them into decision-making process (i.e., democratic behaviour), but less negative nonverbal feedback in response to poor performance (i.e., making angry face), the more they felt their needs to be competent, autonomous, and related to their classmates are satisfied, which, in turn, increased their motivation to participate in PE. The negative indirect effect of situation consideration on self-determined motivation through the perception of competence was surprising, as Zhang and colleagues [13] have proposed situation consideration behaviour as a key behaviour that facilitates subordinates perception of competence, which, in turn, would increase intrinsic motivation and self-determi-

ned types of motivation towards particular activity. The possible reason for negative indirect effect of perceived situation consideration behaviour on 12th graders self-determined motivation might be that they probably to not prefer their teacher assigning them to the appropriate game positions in lessons (i.e., situation consideration behaviour). This kind of teacher's behaviour may provide students with the information that they cannot manage to play in different game positions, provoking the feelings of incompetence, which, in turn, will diminish the intrinsic motivation and self-determined types of motivation in PE. Finally, path-analytic models indicated that perceived autocratic behaviour had negative and direct effect on self-determined motivation for both 7th and 12th graders. This is consistent with previous studies in sport [1] and PE [7] indicated that both coaches and PE teachers should avoid autocratic decision-making style (i.e., refusing to compromise on a point with students, disliking suggestions and opinions from the students etc.).

In sum, PE teachers should take into account that students with different ages may interpret various teaching behaviours differently. This may cause the discrepancy in magnitude of the effect of various teaching behaviours on self-determined motivation in PE among students with different ages.

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REPEATED SPRINT TEST PERFORMANCE INDICES AND AEROBIC FITNESS IN NORMAL AND OVERWEIGHT PRE-PUBERTAL CHILDREN

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ABSTRACT

We determined relationships between aerobic fitness and performance indices (fastest sprint time – FS, total sprint time – TS, and performance decrement – PD) of repeated sprint tests (RST) in normal and overweight children (BMI%: 59.8 ± 12.9 versus $96.4 \pm 1.9\%$, respectively). Aerobic fitness, FS, and TS were significantly higher in normal weight children. Significant negative correlations were found between aerobic fitness and TS ($r = -0.802$), FS ($r = -0.762$) and PD ($r = -0.670$) in normal weight children. Significant negative correlations between aerobic fitness and TS ($r = -0.767$) and FS ($r = -0.738$), but not with PD were found in overweight children. While aerobic and anaerobic capabilities were significantly higher in normal weight children, strong relationships were found between aerobic fitness and RST indices in both normal and overweight children.

Key words: aerobic, anaerobic fitness, childhood obesity, repeated sprint test Speed, fatigue, anaerobic, endurance.

INTRODUCTION

Children usually engage in short bursts of physical activity separated by brief periods of rest [2]. Accordingly, a typical voluntary physical activity among children includes multi-sprint sports such as soccer and basketball, or games such as tag. The ability of children to sustain intensity during repeated sprints was examined in previous studies [26, 27]. In these studies a wide range of age groups (9–17 yrs.) performed different protocols of repeated sprint tests (RST). It was found that pre-pubertal boys (9.6 ± 0.7 yrs.) needed less recovery time to sustain their peak power output compared to pubertal boys (15.0 ± 0.7 yr) and to young adults (20.4 ± 0.8 yrs.) during repeated cycling sprints [32]. These findings were consistent with Hebestreit et al. [16] and Soares et al. [30], who showed that pre-pubertal children recovered their initial performance faster following high-intensity exercise (peak power or maximum isometric force) than did young adults.

In adults, a high level of aerobic fitness is suggested to be a prerequisite for increased anaerobic performance during repeated sprints [33]. However, correlation between VO_2 max and performance indices of RST have been inconsistent, and only several studies reported significant correlations between the two tests [e.g., 10, 21]. In children, these relationships seem to be especially relevant, due to their characteristic intermittent activity patterns. Moreover, examination of the relationship between aerobic fitness and performance indices of RST is also challenging in unique pediatric populations such as overweight children. This group is particularly important in light of the epidemic of childhood and adolescent obesity in Westernized societies [4]. Both aerobic and anaerobic capacities are reduced in obese compared to normal weight children [12, 20, 34], and as seen in all children, patterns of physical activity among overweight and obese children are also characterized by brief segments of exercise, performed at different intensities and separated by rest intervals of different durations [9, 24]. Better understanding of RST characteristics and their relationship to aerobic fitness in obese children, in comparison to normal weight children, is important and may assist in the design of exercise interventions for obese children. Surprisingly, however, to the best of our knowledge, these relationships were never studied in obese or overweight children. The aim of the present study was to determine the relationship between short

running interval (i.e., 12 × 20 m) RST and aerobic fitness (measured by the distance of a 20 m shuttle run test) in pre- and early-pubertal overweight children and to compare them to pre- and early-pubertal normal weight children. Since in children, there is a faster adaptation of the oxygen transport system during exercise [35], we hypothesized that a significant relationship between indices of RST and aerobic fitness will be found in both normal and overweight children. In addition, we hypothesized those aerobic and anaerobic capabilities of normal weight children will be significantly higher compared to overweight children.

METHODS

Eighteen normal weight (males=9, females=9; 10.1±1.4 yrs), and fourteen overweight children (males=6, females=8; 10.5±1.5 yrs) volunteered to participate in the study. All the overweight children participated in a weight reduction program in the Child Health and Sport Center at the Pediatric Department of Meir Medical Center. The normal weight children studied at a public elementary school of the same geographical region. Body Mass Index (BMI) percentile was assessed in all children as an indication of adiposity. Normal weight was defined as BMI <85%, and overweight as BMI >85%. A physician assessment was performed for pubertal stage by pubic hair [18]. The study was approved by the Institution's ethics committee. The testing procedure was explained to the children and to their parents, and a written informed consent was obtained from both.

Procedure

All the participants, (normal and overweight children) performed two tests: 1. aerobic power test, and 2. 12 X 20 m RST. The tests were separated by a week from each other, and were performed at random order. Before each test, the children participated in a special habituation session which included exercise pattern at the intensity level that was required in the upcoming tests. In order to prevent undesirable effects and/or feelings, each test was performed individually without the presence of other children in the near area. A warm-up procedure, including 5 min of jogging, 5 min of stretching

and 3–5 20 m running repetition at increasing speed, was performed by the participants before each test.

Performance tests

Aerobic Power Test – Twenty-Meter Shuttle Run Test

The 20-meter shuttle run test is a field test that has been shown to be a reliable and valid indicator [31] of aerobic power in various populations including children older than 8 years old [19]. The main reason for the use of this test in the present study to evaluate aerobic fitness was its back and forward run which best characterizes children's voluntary activity patterns. The test consists of shuttle running at increasing speeds between two markers placed 20 m apart. A portable compact disc (Sony CFD-V7) dictated the pace of the test by emitting tones at appropriate intervals. The children were required to be at one of the ends of the 20 m course at the signal. A starting speed of 8.5 km/hour was maintained for one minute, and thereafter the speed was increased every minute by 0.5 km/hour. The test was terminated when the child withdrew voluntarily from the exercise, or failed to arrive within 3 meters of the end line on two consecutive tones. The aerobic fitness of each participant was calculated as the total distance achieved during the test.

Repeated Sprint Test

The RST included a series of short maximal runs with short rest periods between runs. The protocol consisted of 12 X 20 m runs starting every 20 s. A 20 m all-out sprint was performed at the end of the warm-up by each participant. The time for the 20 m sprint was used as the criterion score for the subsequent RST. Participants had rested for five minutes between the criterion sprint and the RST. In the first sprint of the RST, participants were required to achieve at least 95% of their criterion score. This requirement was achieved by all participants.

A photoelectric cell timing system (Alge-Timing Electronic, Vienna, Austria) linked to a digital chronoscope was used to record each sprint and rest interval time with an accuracy of 0.001 s. During the recovery period between sprints, participants tapered down from the sprint they had just completed and slowly walked back to the next starting point. Two sets of timing gates were used, working in opposite directions, to allow participants to start the next run from the

end-point of the preceding sprint. A standing start, with the front foot placed 30 cm behind the timing lights, was used for all sprints. Timing was initiated when the participants broke the light beam. An experimenter was placed at each end of the track to give strong verbal encouragement to each participant at each sprint. Participants were instructed prior to the test to produce maximal effort and to avoid pacing themselves.

The three measures of the RST were the fastest 20 m sprint time (FS), the total sprint time (TS) of the 12 sprints, and the performance decrement (PD) during the test. Total sprint time was calculated as the sum of all sprints times of the test. Performance decrement was used as an indication of fatigue and was calculated as $(\text{Total sprint time} / \text{Fastest sprint time} \times 12 \times 100) - 100$ [13]. The test-retest reliability of the RST is 0.942 for total running time, and 0.75 for performance decrement [13].

Heart rate was measured using a Polar heart rate monitor (Polar Accurex Plus, Polar Electro, Woodbury, NY) immediately after completion of each run in the RST. Rate of perceived exertion (RPE) was determined using the modified Borg scale [8] at the end of the RST.

Statistical analyses

A two-way repeated measure ANOVA with bonferroni adjustments was used to compare differences (total distance 20 m shuttle run, RST's FS, TS, PD, heart rate, RPE) between the normal weight and overweight children. Pearson correlations were computed between the calculated distance during the shuttle run aerobic test and performance indices of the 12 x 20 m RST. Data are presented as mean \pm SD. Significance level was set at $p < 0.05$.

RESULTS

Anthropometric characteristics, performance indices of the RST and the results of the 20 m shuttle run aerobic test of the study participants are presented in Table 1. Overweight children had a significantly greater body weight, BMI and BMI percentiles compared to the normal weight children. The total distance in the 20 m shuttle run was significantly greater in the normal weight compared to the overweight

children. Fastest sprint time and TS were significantly faster in the normal weight children, and RPE at the end of the RST was significantly lower. There were no significant differences in PD and heart rate between the groups.

Table 1. Anthropometric measures, performances indices of the 12 x 20 m RST and total distance during the 20 m shuttle run of the normal weight and overweight pre-pubertal children (Mean \pm SD).

Parameters	Normal weight (n=18)	Overweight (n=14)
Age (yrs)	10.4 \pm 1.2	10.6 \pm 1.5
Pubertal Stage (Tanner)	1.1 \pm 0.3	1.2 \pm 0.4
Body Height (m)	141.0 \pm 9.9	143.5 \pm 7.9
Body Weight (kg)	36.3 \pm 6.6	52.5 \pm 10.0*
BMI (kg/m ²)	18.1 \pm 1.5	25.1 \pm 4.7*
BMI Percentile (%)	59.8 \pm 12.9	96.4 \pm 1.9*
Fastest Sprint (sec)	4.10 \pm 0.34	4.71 \pm 0.65*
Total Sprint Time (sec)	52.99 \pm 4.95	60.03 \pm 9.05*
Performance Decrement (%)	7.74 \pm 3.55	6.36 \pm 3.62
Maximal Heart Rate (beats/min)	197.2 \pm 8.9	191.0 \pm 7.1
RPE Score	3.8 \pm 1.4	5.1 \pm 1.5*
Distance-20m Shuttle Run (m)	752.6 \pm 401.7	468.6 \pm 107.4*

* $p < 0.05$, normal versus overweight

The correlations between the 20 m shuttle run aerobic test and performance indices of the RST are presented in Figure 1. Significant negative correlations were found between the distance in the 20 m shuttle run aerobic test and the TS ($r = -0.802$), FS ($r = -0.762$) and the PD ($r = -0.670$) of the RST in the normal weight children. Similarly, significant negative correlations were found between the distance in the 20 m shuttle run aerobic test and the TS ($r = -0.767$) and the FS ($r = -0.738$) of the RST in the overweight children. There was no significant correlation between the distance in the 20 m shuttle run aerobic test and the PD in the RST in the overweight children.

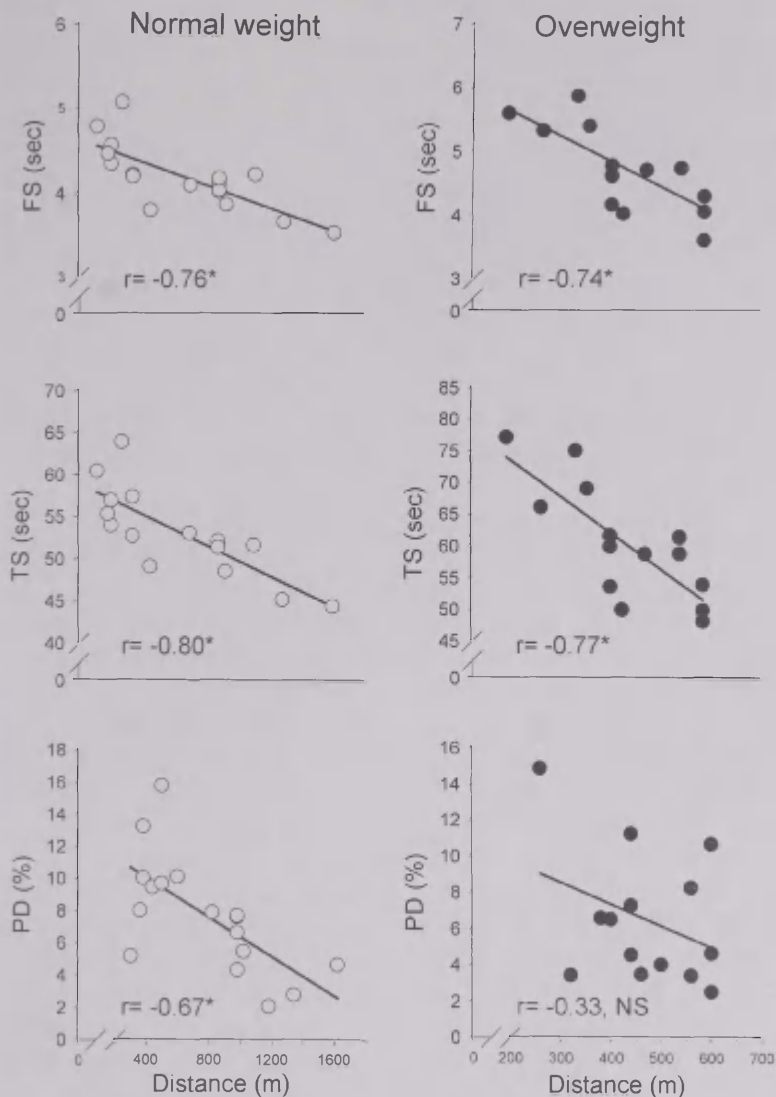


Figure 1. Relationships between the total distance in the 20 m shuttle run and performance indices of the 12 x 20 m RST in normal weight (left panel) and overweight (right panel) children. FS: fastest sprint time; TS: total sprint time; PD: performance decrement; NS: non-significant; * $p < 0.05$.

DISCUSSION

The present study examined the relationship between aerobic fitness (measured by distance in 20 m Shuttle Run) and performance indices of 12 X 20 m RST in normal weight and overweight pre- and early-pubertal children. The results clearly indicated that the aerobic fitness of the normal weight children is higher than overweight children (Table 1). Our findings are in agreement with the results of Marinov et al. [20] who demonstrated that the aerobic fitness of non-obese children was significantly higher than obese children. Consistent also with our findings, the RPE of the obese children, in their study, was significantly higher than controls despite a standard workload. It seems therefore, that the aerobic fitness of obese children is reduced and they tend to perceive exertion higher than non-obese children. Both factors may interfere with their ability to sustain prolong physical activity.

The results of the present study also show that FS and TS in the 12 x 20 m RST were significantly faster among the normal weight compared to the overweight children (Table 1). This indicates that anaerobic capacities are reduced in overweight compared to normal weight children as well. Our findings are in agreement with the results of Unnithan et al. [34] who found that anaerobic peak power and total work of normal weight children were significantly higher than overweight children when performing the Wingate Anaerobic Test. The authors concluded that their findings reflect a deficit in anaerobic capacity among children with relatively large body size for their age. This conclusion is in line with the findings of Armstrong et al. [1] who observed a significant negative correlation between skin-fold thickness and peak power or total work of children. The significantly higher body weight and BMI percentile of the overweight children in the present study may have lowered their running efficiency and contributed to the differences in aerobic fitness and RST performance indices between the two groups. The reduced performance among overweight participants might also be related to hypoactivity and muscle contraction characteristics. Cross sectional studies have shown that obese children are less physically active than non-obese children, particularly in spontaneous activities [29]. Although it is unclear whether this hypoactivity can directly influence anaerobic capacity, studies have shown that high-intensity, intermittent training led to improvement in the Wingate Test performance in normal weight

children [28]. In contrast, similar type of training did not result in an increase anaerobic capacity in 12–16 years old obese boys [11]. In addition, evidence exist that obese adolescents have a lower percentage of motor unite activation during knee extension compared to leaner adolescents [7]. This finding implies that, for a given muscle mass, less power can be generated. The contributing role of hypo-activity and reduced muscle unit characteristics for the reduced pereformance of overweight children in the present study remains speculative since we did not determine these factors.

The present study also examined the relationships between the aerobic fitness and the performance indices of the 12 X 20 m RST. Significant strong negative correlations were found between the aerobic fitness and the TS and PD of the normal weight children and between aerobic fitness and the TS of the overweight children (Fig. 1). Although PCr resynthesis appears to be controlled by the rate of oxidative metabolism within the muscle [32], previous studies have found that correlation analyses between VO_2 max and performance indices of RST have been inconsistent, and while some authors reported significant moderate correlations between the two [10, 14], others have failed to do so [23]. However, previous studies found a higher muscle oxidative activity [6, 15], a greater relative volume density of mitochondria [5] and a faster adaptation of the oxygen transport system [35] in children compared to adults. These experimental data have been supported by Taylor et al. [32] who showed that the rate of PCs resynthesis after maximal exercise were two-fold higher in children aged 6–12 y compared with adults aged 20–29 y. In accordance with these, Ratel et al. [27] found boys (11.7 ± 0.5 y) to maintain more easily running performance than adults (22 ± 2.9 y) during repeated treadmill sprints separated by 15 s rest. The greater reliance of children on oxidative metabolism is consistent with the finding of significant high correlations between the aerobic fitness and the TS and PD in the RST of the normal weight children and between the aerobic fitness and the TS in the RST of the overweight children in the present study. The lack of significance in the relationship between aerobic fitness and PD of the overweight children may be explained by the remarkable overall slow running speed of the overweight children, and/or by the great heterogeneity of running skills and running efficiency among the overweight children. Reduced running efficiency may affect performance mainly during all out sprints [22],

as was required in the RST of the present study, and could have masked the relationship between aerobic capacity and PD during RST in the overweight children.

The aerobic fitness was also significantly correlated with the FT in the RST of the normal weight and the overweight children in the present study. These findings are in contrast to previous reports indicating that the aerobic components of a single short sprint (≤ 10 sec) are very small ($< 10\%$) in adults subjects [3, 25]. However, as seen in normal weight boys [17], the results of the present study may suggest that oxidative metabolism plays an important role, and serves as an energy source, even during a single sprint in normal and in overweight pre-pubertal children. This finding is consistent with the notion of greater reliance of children on oxidative metabolism, and with the theory that the metabolic specialization phenomenon (aerobic versus anaerobic preference) occurs in adults but not in pre- and early-pubertal children [4].

In summary, in prepubertal children the aerobic fitness and the anaerobic capabilities, as reflected by RST performance indices, of normal weight children are significantly higher than overweight children. The results also indicate that aerobic fitness plays an important role in intense intermittent activity in normal weight and in overweight children. Finally, the results of the present study suggest that oxidative metabolism may serve as an energy source, even during a single sprint in normal and in overweight children. Further studies are needed to clarify the relationships between the aerobic and the anaerobic capabilities in normal and overweight children and to determine the relative contribution of the aerobic and the anaerobic energy systems to short all-out exercise in pre- and early-pubertal children.

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LEG EXTENSOR MUSCLE VOLUNTARY ISOMETRIC FORCE PRODUCTION CAPACITY IN CHILDREN WITH SPASTIC DIPLEGIA

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ABSTRACT

The aim of this study was to compare the isometric force production capacity of the leg extensor muscles in 9–12-year-old children with spastic diplegia (SD; 11 girls and 10 boys) and age- and gender-matched nondisabled children (11 girls and 10 boys). Isometric maximal voluntary contraction force of the leg extensor muscles was measured during unilateral and bilateral contractions (leg press exercise) using custom-made dynamometric chair. Children with SD had significantly ($p < 0.05$) lower isometric maximal force during bilateral and unilateral contractions compared with healthy children. Bilateral strength deficit did not differ significantly in children with and without SD. No significant correlations between isometric force characteristics of the leg extensor muscles and anthropometric parameters were observed in children with SD. These results indicated that in children with SD, isometric voluntary force-generating capacity of the leg extensor muscles during bilateral and unilateral contractions is markedly reduced, whereas bilateral strength deficit is not differ compared with age- and gender-matched healthy children.

Key words: muscle force, bilateral strength deficit, cerebral palsy, children

INTRODUCTION

Cerebral palsy (CP) is an umbrella term for a group of frequent disorders of motor function due to a nonprogressive lesion of the developing brain. The factors related to the impaired motor function in children with CP are spasticity, paresis, lack of motor control in the affected limbs, and dystonia [1]. Spasticity and lack of muscle strength (weakness) are primary impairments associated with CP. It has been shown that low muscle strength, and not spasticity, causes the greatest limitations in motor function in children with CP [22]. Muscle function often becomes progressively more compromised in CP, leading to reduced mobility [3]. Spastic diplegia (SD) is one of the most prevalent type of CP [1]. Muscle force production is an important component of neuromuscular function, which is necessary for the performing of tasks of daily living. Isometric voluntary maximal force (MF) of the muscles of lower extremities has been used for measuring neuromuscular performance in young children with different physical disabilities, including children with SD. It has been suggested that children with spastic SD have significant amounts of lower extremity weakness, i.e., decreased MF compared to their able-bodied peers [7, 25]. This weakness may limit the performance of activities and participation in daily life [26].

A reduction in isometric MF induced by simultaneous bilateral (BL) contraction as compared to the sum of MF of separately performed unilateral (UL) contractions has been reported in adult subjects, and this phenomenon is designated as bilateral strength deficit (BLD) [12, 23, 24]. The neurophysiological mechanisms underlying BLD in human muscles are not well understood. Therefore, one explanation for the BLD is that it could be neural interaction between the two hemispheres connected by commissural nerve fibres [11, 15]. BLD has been associated with reduced movement-related cortical potentials caused by a mechanism of interhemispheric inhibition [15, 16]. It has been suggested that BLD can be caused by a reduced activation of higher threshold (fast) motor units [18]. BLD can also be a consequence of a disproportionate increase in coactivation of antagonist muscles [9]. A marked BLD would suggest a significant limitation of motor control. It has been supposed that despite BL lower extremity involvement, the majority of children with SD have the capability to ambulate, albeit at a later age and less

proficiency than normally developing peers [19]. Less information is available in regard to lower extremity BLD in children with and without SD [28]. Most studies of muscle force in children with SD have been performed in UL contraction condition. However, investigation BLD in lower extremity muscles can increase our knowledge concerning muscle weakness and motor control impairment in children with SD.

The purpose of the present study was to compare the isometric force production capacity of the leg extensor muscles during UL and BL contractions, and BLD in 9–12-year-old children with SD and age- and gender-matched nondisabled children. Leg extensor muscles play an important role in motor activities of daily living, e.g. rising from a chair, standing and gait.

MATERIAL AND METHODS

Subjects

Twenty one prepubertal children aged 9–12 years (11 girls and 10 boys) with SD and 21 age- and gender-matched children without disabilities (11 girls and 10 boys) participated in this study. The anthropometric parameters of the subjects are presented in Table 1. Inclusion criteria for CP children were: 1) diagnosis of spastic diplegia, 2) presence of spasticity with a rating of 2 or 3 on the Modified Ashworth Scale [2], 3) ability to ambulate at least 10 meters without stopping and 4) no fixed contractures or previous surgery on the lower limb. All children were able to follow instructions. None of the children had an impairment of visual, somatosensory, hearing or vestibular function. Pubertal stages were determined according to the criteria of Tanner [27] by a pediatrician of the same gender as the subject. The children were classified as prepubertal if pubic hair and genital development for boys and breast development and pubic hair for girls were both scored as stage 1. Informed parental consent was obtained prior to the children's participation in the experiment. The study carried the approval of the University Ethics Committee.

Table 1. Anthropometric parameters of the subjects groups (mean \pm SE).

Variable	Children with SD	Healthy children
Age (years)	10.4 \pm 0.2	10.5 \pm 0.2
Height (cm)	136.6 \pm 2.2	138.1 \pm 2.3
Body mass (kg)	32.7 \pm 3.3	31.8 \pm 2.9
Body mass index (kg·m ⁻²)	17.4 \pm 1.2	16.8 \pm 1.0

SD – spastic diplegia

Apparatus and Experimental Protocol

The subjects were seated on a specially designed dynamometric chair in a horizontal frame with knee and hip angles equal to 110° and 120°, respectively [28]. The body position of the subjects was secured by two Velcro belts placed over the chest and hip. The feet were placed on a footplate mounted on a steel bar held in ball-bearings on the frame. The isometric force production of the leg extensor muscles was recorded by standard strain-gauge transducer (1778 DST-2, Russia) connected with footplate. Signals from the strain-gauge transducer were linear from 0 to 20 000 N. The force signals were sampled at frequency of 1 kHz and stored in a hard disk of a computer using software WsportLab (Urania, Estonia). Acceptable reliability of isometric MF of the leg extensor muscles during BL and UL contractions in children using this dynamometer was demonstrated in our previous study [28]. Test-retest correlations with a 1-week interval between measurements in this study was $r = 0.86$ – 0.92 in 6-year-old boys and $r = 0.82$ – 0.89 in age-matched girls.

Isometric MF of the leg extensor muscles was measured during UL and BL contractions (leg press exercise). During testing the subjects were instructed to push the footplate as forcefully as possible for approximately 3 s in three cases: 1) UL contraction of the right leg, 2) UL contraction of the left leg and 3) BL contraction. Three maximal attempts were recorded for each case and the best result was taken for further analysis. Strong verbal encouragement and visual online feedback were used to motivate the subjects. A rest period of 2 min was allowed between the attempts. During UL exertions the contralateral leg was allowed to rest. Bilateral index (BI) was calculated by the formula [9]:

$$BI (\%) = 100 [BL / (UL_R + UL_L)] - 100,$$

where BL is isometric MF during bilateral contraction, UL_R and UL_L are isometric MF during right and left leg unilateral contractions, respectively. A negative BI indicated a BLD, while a positive BI indicated a BL facilitation.

Twenty-four to 48 hours before data collection the subjects were given instructions and the strength testing procedures were demonstrated. This was followed by a practice session to familiarize the subjects with the procedures. The same researcher with long-term experience in this kind of testing procedure tested all subjects between 11 am and 3 pm.

Statistical analysis

Data are means and standard errors of mean (\pm SE). One-way analysis of variance (ANOVA) followed by Tukey post hoc comparisons were used to test for differences between groups of children. Linear correlations were calculated to observe the relationship between the measured characteristics. A level of $p < 0.05$ was selected to indicate statistical significance. The main measured characteristics of the leg extensor muscle isometric force production between children with SD and healthy control children were tested for statistical significance ($\alpha = 0.05$). Statistical power analysis demonstrated that 21 children in each group is a sufficient number to detect significant differences ($\beta < 0.80$) in BL (0.92), UL_R (0.94) and UL_L (0.90). However, 25 participants in each group were required to provide sufficient power (0.80) for BI.

RESULTS

The mean values of measured anthropometric characteristics (height, body mass and body mass index) did not differ significantly ($p > 0.05$) in children with SD and age- and gender-matched nondisabled controls (Table 1). As shown in Fig. 1A, isometric MF of the leg extensor muscles during BL contraction was less ($p < 0.05$) in children with SD compared to healthy controls. In children with SD, isometric MF during right and left leg UL contraction was also less ($p < 0.05$) than in healthy controls (Fig. 1B). No significant differences ($p > 0.05$)

in isometric MF between the legs were observed either in children with SD or healthy controls. As shown on Fig. 1C, BI did not differ significantly in children with SD compared to controls.

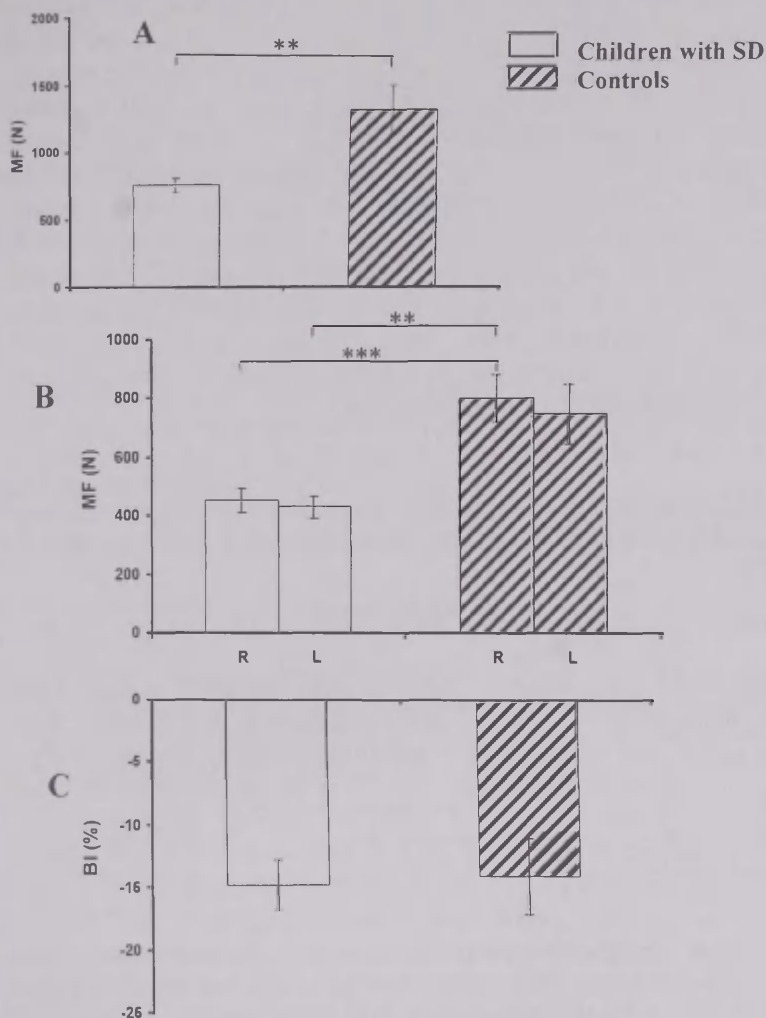


Figure 1. Mean (\pm SE) isometric maximal force (MF) of the leg extensor muscles during bilateral contraction (A) and during unilateral contraction of the right (R) and left (L) leg (B), and bilateral index (BI) (C) in children with spastic diplegia (SD) and healthy control children. ** $p < 0.01$; *** $p < 0.001$.

No significant correlations ($p>0.05$) were found between isometric MF of the leg extensor muscles during BL and UL contractions, BI and anthropometric characteristics in children with SD (Table 2). Significant ($p<0.05$) positive correlations were observed between isometric MF during BL contraction, and MF during right and left leg UL contractions ($r=0.77$ and $r=0.88$, respectively) in children with SD. The height, body mass and body mass index of healthy control children correlated significantly ($p<0.05$) positively ($r=0.72$ – 0.86) with isometric MF of the leg extensor muscles during BL and UL contractions (Table 3). Significant ($p<0.05$) positive correlations were observed between isometric MF of the leg extensor muscles during BL contraction, and MF during right and left leg UL contractions ($r=0.96$ and $r=0.93$, respectively) in control children. No significant ($p>0.05$) correlations were found between BI, anthropometric parameters and isometric MF of the leg extensor muscles during BL and UL contractions in control children.

Table 2. Correlations between anthropometric parameters and leg extensor muscle isometric force production characteristics in children with SD ($n=21$)

Variable	Height	Body mass	BMI	UL _R	UL _L	BL	BI
Height	X	0.95*	0.70*	-0.14	0.05	-0.08	0.09
Body mass		X	-0.04	-0.08	0.24	0.11	-0.10
BMI			X	-0.04	0.36	0.22	-0.23
UL _R				X	0.45	0.77*	0.32
UL _L					X	0.88*	-0.25
BL						X	-0.25
BI							X

SD – spastic diplegia; BMI – body mass index (body mass/height²); UL_R – isometric maximal force (MF) during unilateral contraction of the right leg; UL_L – isometric MF during unilateral contraction of the left leg; BL – isometric MF during bilateral contraction; BI – bilateral index.

* $p<0.05$.

Table 3. Correlations between anthropometric parameters and leg extensor muscle isometric force production characteristics in healthy children (n=21)

Variable	Height	Body mass	BMI	UL _R	UL _L	BL	BI
Height	X	0.88*	0.73*	0.75*	0.86*	0.74*	0.27
Body mass		X	0.96	0.79*	0.85*	0.80*	0.06
BMI			X	0.72*	0.76*	0.74*	-0.02
UL _R				X	0.91*	0.96*	-0.01
UL _L					X	0.93*	0.09
BL						X	-0.21
BI							X

BMI – body mass index (body mass/height²); UL_R – isometric maximal force (MF) during unilateral contraction of the right leg; UL_L – isometric MF during unilateral contraction of the left leg; BL – isometric MF during bilateral contraction; BI – bilateral index.

* p<0.05.

DISCUSSION

A markedly reduced isometric voluntary force-generation capacity of the leg extensor muscles during BL and UL contractions (leg press exercise) in 9–12-year-old children with SD compared to age- and gender-matched nondisabled children was observed in this study. In children with SD, isometric MF of the leg extensor muscles during BL contraction was on an average of 43% lower than in healthy controls. Children with SD produced on the average by 43% and 42% lower isometric MF of the leg extensor muscles during right and left leg UL contractions, respectively, than the healthy children. This is in agreement with the results of several previous studies [7, 25], indicating a significant reduction of isometric voluntary force production capacity of the muscles of lower extremities in children with SD. For example, Stackhouse et al. [25] demonstrated 73% less isometric MF of the plantarflexor muscles in boys with CP (with mean age of 10.5 years) compared to the control group. Damiano and Abel [5], who measured isometric voluntary force production capacity of eight muscle groups in both lower extremities with a hand-held dynamo-

meter in children with SD, observed a significantly reduced isometric MF in diplegic children in all measured muscle groups compared to age-matched children.

Impaired central motor drive and coactivation of the antagonist muscles across the joints, and disuse atrophy can hinder the isometric force production in the lower extremities in children with SD. Voluntary force-generation capacity of muscles is highly dependent upon the degree of motor unit activation, which is influenced by the development of the central nervous system. Low voluntary force production in CP has been attributed to either incomplete motor unit recruitment or decreased motor unit firing rate during maximal voluntary contraction [5, 20]. The reduced isometric MF of the skeletal muscles in children with CP could be partly attributable to a reduced ability to recruit higher threshold (fast) motor units or to drive lower threshold (slow) motor units to higher firing rates [4, 20]. Increased antagonist coactivation could also contribute to measured deficit in voluntary muscle force production in CP [6, 7]. It has been suggested that children with CP often demonstrate excessive amount of cocontraction of antagonist muscles in the lower extremities during muscle force testing [6]. Spasticity, defined as hypertonicity and hyperreflexia [14], may be one of the major factors responsible for the increased amount of cocontraction of antagonist muscles in diplegic subjects. Therefore, increased levels of cocontraction of antagonist muscles may restrain the action of the agonist muscles and reduce force output in children with SD.

Another source of CP-related muscle weakness may be the occurrence of significant structural and mechanical changes in skeletal muscles. The most common findings in CP are an increased incidence of muscle fibre atrophy, increased intramuscular fat and connective tissue in the most involved muscle groups [3, 21], and increased percentage of slow-twitch (type I) muscle fibres [10, 21]. Histological and histochemical studies have also showed mild myopathic changes in muscles and atrophy of type I and type II muscle fibres in children with CP [21]. Ito et al. [10] reported a selective atrophy of type II muscle fibres during development in CP. Moreover, during growth there occurs progressive fibrosis and the number of sarcomeres does not increase as rapidly as in children without CP. An abnormal variation in the size of muscle fibres and myosin heavy chain expression has been found in children with spastic CP [21]. It has been suggested that muscle cells in patients with spasticity are shorter

and stiffer than normal muscle cells [8]. Elder et al. [7] demonstrated that muscle weakness in plantarflexor muscles in subjects with CP is based partly on reduced muscle cross-sectional area and an inability to produce torque levels commensurate with cross-sectional area. One of our previous studies [29] indicated that prepubertal children with SD in comparison with normal children are characterized by markedly reduced isometric voluntary and electrically evoked twitch contraction maximal force, capacity for twitch postactivation potentiation, and rates of twitch force production and relaxation of the plantarflexor muscles. These peripheral factors can reduce muscle force-generation capacity in children with SD.

A negative BI, i.e. BLD in the leg extensor muscles in all measured 9–12-year-old children was observed in the present study. The mean values of BI in children with SD and their age- and gender-matched controls were –15% and –14%, respectively, whereas difference between these groups was not significant ($p>0.05$). Our previous study [28] indicated that BI of the leg extensor muscles during isometric maximal contractions in 6-year-old children with SD and age- and gender-matched healthy controls was on an average –25% and –22%, respectively ($p>0.05$). Taniguchi [30] indicated that BLD is reduced with bilateral training and increases with unilateral training. However, it has been suggested that bilateral training reduces the BLD, whereas unilateral training has minimal effect on the BLD [13]. The nature of the neural mechanism of BLD must ultimately involve altered motor unit discharge frequency and/or recruitment during maximal voluntary BL contraction. The BLD can be caused by a reduced activation of higher threshold (fast) motor units [18]. The UL muscle contraction is controlled mainly by the contralateral cerebral hemisphere. The BL contraction is considered to be generated by the simultaneous activation of both hemispheres. The mechanisms of BLD have been widely discussed, however, remaining still unclear. Therefore, one explanation for the BLD is that it could be neural interaction between the two hemispheres connected by commissural nerve fibres [11, 15]. BLD was associated with reduced movement-related cortical potentials caused by a mechanism of interhemispheric inhibition [15]. It has been suggested that the BLD may be related to inhibitory spinal reflexes [17]. BLD can be consequence of disproportionate increase in the coactivation of antagonist muscles [16].

In this study, correlation analysis indicated no significant relations between anthropometric characteristics and leg extensor muscle isometric force production parameters in children with SD. Thus, the leg extensor muscle isometric force production capacity is not related with body size in these children. However, in healthy control children, the height, body mass and body mass index correlated significantly positively with isometric MF of the leg extensor muscles during BL and UL contractions. The results demonstrated that the indicator of BLD, i.e. BI did not correlate significantly with anthropometric characteristics and isometric maximal force production parameters of the leg extensor muscles in children with and without SD. Our previous study [28] indicated that in 6-year-old children, BLD was most obvious in children with SD with considerably decreased maximal and body mass-related isometric MF of the leg extensor muscles during BL contraction. However, similarly to the present results, no significant correlations were observed between BI and isometric MF of the leg extensor muscles during BL and UL contractions in healthy children.

In conclusion, the present study indicated that in 9–12-year-old children with SD, isometric voluntary force-generating capacity of the leg extensor muscles during BL and UL contractions is markedly lowered compared to age- and gender-matched healthy controls. The observed BLD in the leg extensor muscles did not differ significantly in children with and without SD. In children with SD, leg extensor muscle isometric force production capacity characteristics are not significantly correlated with body size characteristics.

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SELECT YOUR PARENTS WITH CARE! – THE ROLE OF PARENTS IN THE RECRUITMENT AND DEVELOPMENT OF ATHLETES

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INTRODUCTION

“You must have been lucky in your choice of parents”, a TV-reporter once asked ski-legend, Bjørn Dæhli jokingly, but with a fumbling seriousness in trying to establish what was behind his success. “Yes, I must have been” was the answer after some pondering, and with a knowing smile. Bjørn Dæhli is well known as the most winning winter Olympic athlete in history. He is, however, not alone in his accord, more or less, with his provocative statement. Many other successful athletes have, after some musing, nodded to this in confirmation that they could not be fully sure that this was not also their recipe. Expressions in this direction can be viewed as a consequence of athletes being confronted with perspectives and expectations that they fully alone should have control over their success-factors. The inherited characteristics really do not fit into this self-controlled picture. In a package wrapped in humour, however, this self-control mythology can be sustained. Thereby is it possible to achieve a dim confirmation that the right genes must be in place. Then, an advantage over the competitors can already be present from the start, and it may very well be just this that competitive sport is mainly about. The remaining advantages, many believe, are still within the individual’s control, cultivating further the myth of the athletic talent.

The consequence of this recognition is that the problem area of the relationship between genetic inheritance and cultural factors emerges,

including the fact that no-one can have influence over their genetic make-up. It follows, therefore, that it is not possible for the individual to have full control over athletic achievements. Parents represent both dimensions of performance, but parents are not up for selection. Even though genes compose very specific points of departure for athletic achievements, there are probably so far only largely random events that orchestrated their selection and fusion within the apparent "cosmic chaos". The question then remains to what degree and in which ways parents are also formative participants in the development of talent through their socio-cultural contributions.

A great deal of mythology has been spun about talent in sport. Generally the understanding of "talent" has been linked with genetic sources, much related to the idea of identifying talent already in childhood. Even today it is still argued that talents have been identified among children, as a forecast of future elite performers in sport. Despite the fact that some do succeed, the foundation for this prediction is thin. Neither personality nor identity are strongly anchored in the child as the basis for motivation and commitment, and neither is anything known of future resources for development in the interaction between personality and external access to resources. If the concept of talent is to be of use in serious dialogue and communication, then it is paramount that those involved have some commonality in their understanding of the term. In an attempt to clarify the issue, the following definition of talent is offered; a definition that guides the present work:

An athletic talent is characterized by the sporting achievements the individual has demonstrated as possessing the potential to reach, dependent on sufficient associated motivation, effort, and resources of varying type, size, and quality on an open-ended scale.

This means that there will always be discussion about the degree of talent. An unknown part of the talent's potential lies in the genes, whereof in many sports a number of concrete physiological parameters are known.

A highly talented performance level is, however, not only a result of inborn characteristics, but to the greatest degree a product of voluminous goal-directed training [16]. An optimization of this training is conditional on good motivation, great effort, and large resources of many kinds. The closely associated question then is how such motivation, effort, and resource-base emerges? While motivation

and will to apply effort lie within the athlete, the resources needed are both of internal character in the athlete's personality, and of external character such as economy, knowledge, infrastructure, access to transport, equipment and materials of various types, etc. All these interact in dynamic fashion.

The absolutely fundamental condition for development of talent in sport is that the athlete – to-be is recruited to the athletic setting. This takes place in a social context composed of the family and possibly a coach, in addition to the child [36]. The family's importance for the achievement of high performance-capacity has been in the spotlight in several studies. However, the search is still on for the specific family-behaviour that has the greatest socialization-impact on children's participation in sport throughout their development [12]. The influence of siblings in the dynamics of the family is also a field that to a great extent has been overlooked in the study of sport. Although the same cannot be said of friends, even here there is a continued lack of a clear unraveling of their role.

On this foundation the following problem is addressed in this investigation:

What role and consequence have parents in the recruitment and development of talents in the sport of cross country skiing?

The impetus for this query was the juxtaposition of several decades of intense experience by the authors with cross country skiing in Scandinavia and North America. How Scandinavia, in spite of its modest population, has historically dominated this sport, was a question that needed resolution. That it was not a lack, in North America, of science-based knowledge of human performance variables, or a deficiency in technological competence or resources, was clear. *Au contraire*, reflection led to the socio-cultural arena in the search for answers, and in particular to that most *significant other* context of family. In Norway, success on the ski-trail has commonly been seen as an expression of socio-cultural forces [24].

REVIEW OF THE LITERATURE

Parents as Role-models in the Socialization to Sport

If parents are experienced as good role-models, then children prefer to identify with them. Through observation and acting like them, the

children go through a process of socialization towards a more established identity as an individual. Simultaneously can parents contribute to a reinforcement of a desired identity-development through rewarding and encouraging behaviour. These relationships were indicated through the inquiries which shaped the foundation of the social-cognitive perspectives of Bandura [3]. The sum of habits, expectations, and interpretations of social contexts informed Bourdieu toward the concept of "*habitus*" (2002). This implies that all that contributes to form the daily life of a family, such as social inheritance, education, occupation, income and capital, social environment, residence, relatives, and friends, will in sum connect the family to a culture or subculture. This is expressed through a familiar lifestyle of some form, and carries consequences for the relatively malleable children. It is therefore close at hand to expect a relationship between parental athletic activities and the recruitment of their children to sport. This is the first element in the foundation for the further development of athletic talent.

A confirmation of this is found in the investigation of elite sport in Norway, "*Why did the best become best?*" [6]. It was based on in-depth interviews of the 18 most successful Norwegian athletes in Olympics, World Championships, and World Cup in 10 different sports. The subjects were anonymized, but in a ski-nation such as Norway, they would perforce have included some skiers. The results showed that 72.2% indicated that both parents were involved in some form of sport or physical activity. A full 58.8% took part in competition at a regional or national level, or 42.5% of all parents in the study. In comparison, only 4 of 10 in the Norwegian population at large are regularly physically active. Concerning the specific socialization effects, it is to be noted that as much as 57.7% of the athletically active parents were engaged in the same sport that their children would become world class in. In-depth interviews by Côté [12] in Canada of top junior athletes and their families showed that all parents were involved in organized sport at the recreational level. However, in that study, only 25% had at least one parent with competition background.

Further confirmation in this direction has been gained from two other Norwegian studies. In Bergsland's (2003) investigation of 250 young talented cross country skiers and soccer players, it was concluded that the family was the most important factor in the athletic

development. The second study, by Mjaavatn and Gundersen [28] was a 4-year longitudinal investigation of 100 children from first to fourth grades, and their families. The focus was on the degree of physical activation, and its consequences. They concluded that children of this age-range are primarily products of their families, and that family lifestyles to a very high degree affect child physical activity levels.

Other investigations have also set the spotlight on the importance of parents shaping their children's positive values, attitudes, and behaviour directed to sport and physical activity. Some of these studies show that parents as role-models can also be gender-influenced [11, 19, 32]. Still other inquiries have found that parents of sport-engaged children in varying degrees support values related to learning, hard work, activity, endurance, and success [13, 29, 38, 39, 41].

There is also documented a positive relationship between encouragement from parents and physical competence of children [8]. Play and athletic activity by parents *with their children* is a characteristic trait in the positive parental role all the way up to the children's age of 15 [5, 12, 40].

Parental Support

Several studies have reported the significance of the parental supportive role for children who are involved in sport. Hellstedt [21] conceptualized parents' involvement in child participation in sport on a graduated scale from under-involved, via moderate-, to over-involved. The moderate level he describes as the best for promoting the child's interest, even though it meant that parents must sacrifice personal interests. Bloom [5] emphasized the considerable influence of the family in the different stages of child development in science, art, and sport. In the early years of child engagement in an activity, the parents tended to be supportive while simultaneously the child experienced freedom. This phase was followed by a period of devotion to the activity for both child and parents. Finally, the later years were characterized by the participant's fulltime commitment to performance-capacity improvement, with a parental role more restricted to primarily providing economic support. Bloom indicated with this a developmental perspective for the family's influence on evolving talent. This view has been supported by Hellstedt [20]. In this regard, Van Yperen [47] reported further that parental support

also has a buffering function, dampening the stress of competition for the child.

Côté [12] suggested the existence of three defined stages in sport-participation; the "sampling years" (6–13), the "specializing years" (14–15), and the "investment years" (over 15). His studies showed that the parental role changed from a leadership role in the "sampling years" to a support and follow-up role in the "investment years". An important condition for taking care of recruited children and preventing their dropping out from sport during their first development phase has been the joy and fun of sport, and the experience of growing skill-mastery through minimizing competition-stress [12, 20] In the "specializing years", Côté [12] notes that the parents became committed supporters of their children's decision of involvement in a restricted number of sports. The parents exert no pressure on their children concerning which sport they should specialize in. They also stress that priority be placed on school and sport, and do not expect that the child should have part-time work in the years of specialization. The extra pressure of part-time work they wished their children to avoid, since this life-phase is to be regarded as a one-time opportunity in relation to athletic development. The consequence of this was that parents took responsibility for both the necessary financial resources as well as the time needed. Often they were obliged to make sacrifices in their own social life and time for recreation.

In the "investment years" the child would connect to only one sport. Training loads grew to be extreme and disciplined, with performance at the elite level as the objective. The role of the parents as infrastructure and supporters became more clear during this period, and they sacrificed both family and personal life in order to ensure optimal training conditions for the child. Parents responded to the fluctuating demands and expectations their children were exposed to by shaping an optimal learning setting instead of exerting new demands and pressures. They entered into a number of roles that strengthened the setting for their child's sport participation, and became important career advisors. A vital characteristic for this period is the significance of the emotional support from parents in periods where downturns and problems have curbed the progression of training. Injuries, exhaustion, stress, fiasco, or wavering of motivation may from time to time be characteristic of any athlete's existence.

Soberlak [40] followed up Côté's study by investigating how the formal role of parents changed in tune with the athlete's progression from the "sampling years", via the "specialization years" to the "investment years". Differences among the three periods are that parents in the "sampling years" function as coaches where they structure children's deliberate play, and where transport to training areas constitutes a concrete form of support. During the "specialization years" the parental coaching role ceases while they simultaneously assist with structuring deliberate practice instead of play. These activities they then follow up in the "investment years". Common to all three periods is that they are observers and provide feedback. Similar for the first two periods is that the parents participate together with their children as play- and training-partners. In this way they also function as role-models during two of the athletic talents' important development phases.

A common feature of the studies of Bloom [5], Côté [12], and Soberlak [40], is how the role of parents changes through the three defined developmental stages. Through the "sampling years" the engagement of parents is generally more direct, and consists primarily of play and training *together with the children*. These changes to become more indirect as the children move through the "investment years". During this last phase, the parental role consists largely of being an audience, an economic supporter, and a facilitator for goal-directed training at home such as, for example, a room for strength training.

Parental Expectations

The expectation-concept may for many be a simple and concrete term to be directly related to, and limited to, actual words that parents have spoken. Often this can be correct, meaning that verbal expression and word choice should be carefully chosen in expectation-contexts. Still, there are grounds for a critical stance in this regard, and a reflection if it all is as simple as this. In reality the concept should be subsumed, to a large degree, under the rubric of motivation psychology, the consequence of which leads to greater complexity. Behaviour and other non-verbal signals from the social environment can create higher expectations than those simply verbally expressed. Many more or less hidden signals may be interpreted in ways connected in variable fashion compared to the intentions of the sender. Unintentional/

unconscious signals may also be sent, to complicate the situation yet further. Personal expectations by the athlete emerge through an interaction with this environmental communication repertoire, and can result in expectations greater than those from the social environment *per se*.

On a step-less scale from small-, via moderate-, and large expectations, to possibly significant expectational pressures, there can be motivational consequences of considerable variability. In the scholastic arena, extensive pedagogical research confirms quite unequivocally that expectations and requirements of parents generally contribute to child achievement. Children's decisions to engage in a particular activity, their effort, and the actual performance level reached, were all strongly influenced by parental expectations in a study by Eccles & Harold [15]. These findings received support in investigations indicating that the actual level of children's participation in physical activity is related to the expectations of parents and their belief in their children's physical competence [9, 14, 23]. In a study by Author, Olympic and World medallist cross country skiers expressed that they enjoyed their parents' interest in their skiing efforts and that they had not experienced pressure from them to justify their involvement in the sport.

A study by Brustad [8] showed the relationship between a high degree of encouragement and stimulation from parents, and greater achieved physical competence by children. Several earlier studies have also shown positive relations between expectations of parents and the success of children in sport [27, 35]. However, there are also studies that indicate that expectations can also have a diametrically opposite and negative effect. This can occur when the parental expectations grow so strong that one can speak of great expectation-pressure. The expectations of parents, then, can become a source of stress which may hamper child participation in sport [7, 37, 48]. But here the spectrum of investigation is limited to the participation of children in sport as such, and not to the development of high performance levels through piercing the barriers that this implies in the years of childhood and youth. Nevertheless, the participation in sport *per se* is still the first precondition for later high achievements.

In another study [32] a curvilinear relationship between parental expectation and their children's enthusiasm for swimming was found. High and low expectations were associated with low child enthusiasm,

while a middle expectation level was related to the highest enthusiasm. Although this deals only with the issue of enthusiasm, and not specifically of motivation which leads to a high performance level as an adult, it nevertheless is an important condition for further development. Moreover, swimming is a sport where the elite level can be reached at a young age in comparison with many other sports. The Norwegian study by Breivik & Gilberg [6] of top world class performers in several sports showed that a clear majority had experienced that their parents had small or no expectations of them. The picture of the parental expectation phenomenon that has emerged in sport research appears, thus, both contradictory and unclear.

The issue of expectations as a dimension of motivation psychology comes into force in many fields of life. In the pedagogical research of school and education in general, inquiries into the motivation field are extensive, but without the degree of expectations or demands having received significant attention. However, in the leadership research within the business world, the theme has a central place. An effect that has long been recognized by researchers of learning and behaviour has shown itself applicable to leadership: -the employee's behaviour is shaped by the superior's expectations. If the superior has *great expectations* of an employee it is likely that the latter will work hard to meet these expectations. In the opposite case; -if the superior has *low expectations*, then the employee is likely, over time, to respond with weaker performance. This is described as *self-fulfilling prophecies*, meaning that leaders' expectations of their subordinates shape performance [26]. This relationship he has documented through a series of case-studies of large industrial enterprises.

These studies, then, have revealed dynamics that to a large degree can determine individuals' performance and career development. Valuable characteristics of good leaders are their capacity to shape high expectations of their co-workers, who must stretch themselves in order to fulfil them. Moreover, Livingston has drawn attention to the dramatic consequences that self-fulfilling prophecies can have if they build on negative expectations of performance.

The results of leadership research in business are relevant, however, mainly for adults, and are not to be uncritically applied to children and youth in sporting contexts. Motivation factors for participation or development of high performance capacity in such different arenas may not necessarily be identical.

The question, then, becomes: Can it be that the effect of expectations has something to do with the achievement level that the athlete has reached at given points on their development curve? If so, which degrees of expectations are optimal at what performance levels and developmental phases? An important question, then, is to uncover how different expectations are transmitted and how the athlete perceives them.

Parental Relations, Major Responsibilities, and Socioeconomic Status in the Athlete's Developmental Years

Security and stability in life, as a foundation for a challenging and successful existence, is well documented in developmental psychology. As a consequence of the steadily increasing volume of divorces and dissolved families, significant research attention has been directed to effects this has had for the children involved. Conclusions vary, and may be conditioned by underlying gender-political interests. Less investigated is the degree to which the relationship between parents, responsibility for upbringing, and status, have had for degree of success at the higher levels in sport.

An extensive Norwegian investigation [28], "*Children – Movement – Growing-up Years*" followed a sample of 100 children from the first to the fourth grade in the years 2000 – 2004. Children of single parents were somewhat less physically active, were in somewhat lower physical condition (VO_2 max), and had somewhat poorer motor capacity than children living with both parents. It was also found that fewer single parents were regularly physically active. An explanation for this was that less time may have been available for personal activity compared with parents living together.

In the Norwegian elite athlete study by Breivik & Gilberg [6] referred to earlier, 100% of the subjects lived with both their parents throughout their growing-up period, and 90% experienced a middle-class or higher family economy. Similar findings emerged from Côté's [12] Canadian in-depth interview investigation of successful juniors of national team level, and their families. He found that all came from "intact families" at the middle-class socio-economic level. An extensive study of Swedish national team athletes in several sports by Eriksson [17] showed similar results, ca. 90% having grown up with both parents.

An intact family does not only meet the need for security and stability. There is also good reason to assume that an intact family is also in possession of a larger resource potential. The requirement for resources appears to increase proportionately and often exponentially with the level of performance, this referring to both the athlete's internal and external resources. In this regard then, the dimensions of knowledge as well as economy grow steadily in prominence.

A Norwegian quantitative study [45] investigated the relationship between exercise and sport on the one hand, and economic status and educational level, on the other. A direct and linear relationship was found between household income and the use of money for physical activity. Those who earn the most also use the greatest amount of money for this purpose, in the age-group from 45 years and up. Younger age-groups, of course, have child-rearing costs to deal with. Students with low income, however, spend significant money on physical activity.

There was also found a clear relationship between education and money spent on physical exercise. Individuals with higher education used more resources for this type of activity. A not unexpected relation was also found between the degree of activity and the amount of money spent on them. However, there were not found clear distinctions within most sports, with some important and defined exceptions: Membership in outdoor recreation/education organizations and degree of activation in cross country and alpine skiing was greatest among those with the highest education and income; up to twice that of those at the lowest socio-economic level. Similar relationships were found also for such outdoor activities as cycling and hiking/trekking. The commonality for both is the need for individual equipment and for the somewhat facilitated- or free nature as the activity- and experiential arena. There were no such connections for those using training- or fitness-centres.

METHODS

Quantitative Method

A quantitative method through the use of questionnaire was employed. The use of qualitative methodology such as interview or observation

was ruled out due to the large number of subjects and their dispersed, international location.

Selection of Respondents

The 350 highest ranked cross country skiers (gender not a factor) representing the Norwegian Ski Association (NSF), as well as of the United States Ski and Snowboard Association (USSA), were selected for the study, ca. half from each country. The selection criterion was placement on the International Ski Federation's (FIS) point list.

Access to Respondents

Personal relationship with the administrative head of the NSF and National Team coach was instrumental in gaining access to contact information for the Norwegian athletes. In the United States, the contact information for the skiers was gained through the National Team coach (known from Norway). In addition, the USSA required a written contract stipulating access to the United States portion of the investigation results. In Canada, despite personal contact there, Cross Country Canada declined participation in the study.

Questionnaire Construction

The questionnaire was constructed according to a Likert format [2, 25]. The content had its foundation in the more than 40 years of experience in cross country skiing from each of the authors of the study. The elements of this background were master in sport education, personal competition experience as well as extensive work in the coaching role and in providing technical expertise; from the local to the international level. Personal research background contributing to the study's questionnaire development included the development of the Behavior Inventories for Cross Country Skiers [34].

The questionnaire content was organized according to the following themes:

- Family and Friends
- Supportive Functions
- Childhood Activities
- Environment and Surroundings

- Infrastructure
- Knowledge and Skills
- Barriers
- Control
- Health and Training
- Demographic Aspects

One half of the questionnaire items or indicators were presented as statements or assertions.

The response alternatives were scored on a scale of zero to five, depending on the degree of agreement:

- 5. Yes, I agree completely
- 4. Yes, I agree
- 3. I neither agree nor disagree
- 2. No, I disagree
- 1. No, I disagree completely
- 0. Not relevant for me

It was decided to include a neutral response alternative (nr.3) despite a possible “pole-effect” [30] whereby some respondents may have a disposition to choose the first or last alternative in Likert-type questionnaires. A neutral alternative can enhance study validity in that some subjects may, in fact, not be able to respond any other way. In addition, the inclusion of a neutral alternative makes it possible to score questionnaires where respondents have left some items unanswered. In such cases, these items are scored according to the neutral response alternative.

The sequence of questionnaire items was designed so as to disperse items that could have an interactive effect. Several sequencing variations were pre-tested prior to a final satisfactory solution. Original language was Norwegian, and translation into American English was carried out according to established research practice. Effort was made to achieve short, simple, direct, and grammatically uncomplicated formulations without dialectical, colloquial, or scientific intricacies. The total number of questionnaire items was 100, including 7 underlying theme questions. The questionnaire was largely composed of items from the “Family and Friends” theme, a segment of a broader cross country ski investigation.

Questions Specific to Family

Twelve measures on the socialization-dimension of family were used to compare Norwegian and American skiers. Of the twelve items nine were from the theme "Family and Friends", one from "Environment and Surroundings", and three from "Demographic Aspects".

Pilot Study

The questionnaire was administered to cross country ski coaches and elite athletes, as well as researchers familiar with the sport, in Northwestern USA, Canada, and Norway. As a consequence of constructive feedback, changes were made in question formulations. The revised edition of the questionnaire was sent out again to the coaches and researchers for comment. These were then taken into account, and the final version was successfully tested on a university cross country ski team. Final layout modifications were suggested, and implemented.

Collection of Data

The questionnaire was distributed to 185 skiers in the USA and 165 skiers in Norway. After two weeks, a follow-up letter was sent to those who had not yet responded. Throughout the data collection period there was regular telephone and e-mail contact with the national team coaches in the two countries. This contributed to the high response-percentage from the National Team skiers.

Response Rate

The response rate in the USA was 57.8% (107 out of 185), and 65.5% in Norway (108 out of 165). Included among the respondents was 100% of the National Team in both countries.

Analysis of the Data

The respondents were classified into three performance levels based on the best self reported results from ski races on different levels in their ski career so far. Group 1 was composed of present and former National Team members with international high level performances. Group 2 skiers were lower level performers, while Group 3 was the lowest performance group.

The ranking process for USA was based on the following competition levels:

- National Team member (present or past); but for the year of the study, only elite men's team.
- Results from key competitions (Winter Olympics, World Championships, World Cup, Under 23 World Championships, National Senior or Junior Championships)
- National Collegiate Athletic Association (NCAA) Nordic ski rankings

The ranking process for Norway was based on the following competition levels:

- National Team member (present or past), including elite all-round and sprint teams for the year of the study.
- Results from key competitions (Winter Olympics, World Championships, World Cup, Under 23 World Championships, Scandinavian Cup, National Senior and Junior Championships, Norway Cup).

This classification system resulted in the following number of athlete distribution among the three performance groups in the two countries:

Group 1 Group 2 Group 3

USA 20 68 19

Norway 37 46 25

In the analysis of the data it was found to be appropriate for the purpose of clarity of result presentation and discussion to combine the response categories "Yes, I agree" with "Yes, I agree completely", as well as "No, I disagree" with "No, I disagree completely".

Quality Evaluation of the Study

Reliability and validity were enhanced by the careful process of instrument construction through authors' long-term experience assisted by expert advice from practitioner and scientific personnel. The multi-phase pilot testing of the questionnaire ensured thorough assessment on an empirical basis.

Reliability and Validity

In contrast to so-called differentiated scales, which say something about the strength of a respondent's attitude, in the Likert scale a given declaration is monotone. Attitude strength in the Likert format is expressed by summing scores on similar items, a procedure which finds its basis in classical test theory [42]. Random errors, where observed scores do not reflect true scores, are reduced in such additive scales, thereby strengthening reliability. Attitudes, perceptions, or "orientations" imply a very explicit definition of what Sudman & Bradburn [44] call "attitude objects", which in the present study consists of elements of the socialization process to high level cross country ski performance. The expertise of the authors in the field of study, in conjunction with the multitude of test items covering every sphere of investigation (each item in itself is an expression of expertise), merge to further enhance the reliability of the investigation. Reliability was ensured as well through the careful pre-testing of the questionnaire.

In relation to validity, there is no assurance that all items in additive scales in fact measure what they are designed to measure. The cancelling-out tendency of random errors in additive scales partially addresses this issue; however, systematic errors, or bias, is a serious challenge to validity. In the present study, systematic misunderstanding of items was unlikely in view of the meticulous instrument pre-testing procedure. A "social desirability" bias [31], on the other hand, could have affected the findings. This broadly recognized bias problem, today often termed the "politically correct" bias, was met partially by the nature of the research theme, and partially by thorough methodology. First, the study did not deal with matters which might be perceived as delicate, sensitive, or very private by the respondents; thus there was little reason to distort responses. Secondly, anonymity was, nevertheless, ensured by written information guaranteeing this through sealed questionnaire envelopes, assurance of no identity registration, and an analysis of the research data wherein all information was depersonalized. Taken together, these aspects of the investigation indicate robust validity.

RESULTS

The results of the study are presented under headings replicating item formulations in the questionnaire. In addition to the presentation of data in table form, there is associated textual commentary and graphic representations which show the results from those responding to the statements and questions.

1) "In my childhood I was often together with my family skiing".

Table 1a: Norway

		Frequency	Valid Percent	Cumulative Percent
Valid	3	8	7,4	7,4
	4	16	14,8	22,2
	5	84	77,8	100,0
	Total	1018	100,0	
Missing System		109		
Total				

Percentage agree (14,8 %) and completely agree (77,8 %) = 92,6 % (bold script)

Table 1 b: USA

		Frequency	Valid Percent	Cumulative Percent
Valid	1	7	6,4	6,4
	2	13	11,9	18,3
	3	9	8,3	26,6
	4	1	0,9	27,5
	4	29	26,6	54,1
	5	50	45,9	100,0
	Total	109	100,0	

Percentage agree (27,5 %) completely agree (45,9 %) = 73,4 % (bold script)

In the Norwegian segment of the study, fully 92.6% of the respondents agreed, or completely agreed, with this statement. The USA comparison was 73.4%, also quite a high figure, although the 19.2% difference could be viewed as considerable.

2) "One or both of my parents have been competing in cross-country skiing"

Table 2 a: Norway

			1	2	3	4	5	
Group	1	Count	18	3	3	3	10	37
		% within group	48,6%	8,1%	8,1%	8,1%	27,0%	100,0%
	2	Count	18	5	1	8	14	46
		% within group	39,1%	10,9%	2,2%	17,4%	30,4%	100,0%
	3	Count	8	2	3	3	9	25
		% within group	32,0%	8,0%	12,0%	12,0%	36,0%	100,0%
Total		Count	44	10	7	14	33	108
		% within group	40,7%	9,3%	6,5%	13,0%	30,6%	100,0%

Percentage agree and completely agree (bold script) are combined for each group and for the total

Table 2 b: USA

			Question 2						Total
			1	2	3	3	4	5	
Group	1	Count	5	3	2	0	5	5	20
		% within group	25,0%	15,0%	10,0%	0,0%	25,0%	25,0%	100,0%
	2	Count	22	7	4	1	20	14	68
		% within group	32,4%	10,3%	5,9%	1,5%	29,4%	20,6%	100,0%
	3	Count	8	1	1	1	4	4	19
		% within group	42,1%	5,3%	5,3%	5,3%	21,1%	21,1%	100,0%
Total		Count	35	11	7	2	29	23	107
		% within group	32,7%	10,3%	6,5%	1,9%	27,1%	21,5%	100,0%

Percentage agree and completely agree (bold script) are combined for each group and for the total

The results from the two countries are relatively similar. While in the United States, 48.6% agreed or completely agreed with the statement, the figure for Norway was 43.6%. A more detailed analysis according to performance level showed a corresponding pattern, with one clear exception. In the United States, 50.0% of the top performance group had parent background in competitive skiing, while in Norway the figure was as low as 35.1%. The relative pattern of the groupings in the two countries was also striking. In the U.S.A., the Group 2 and 3 figures were 50.0% and 42.2%, respectively, while in Norway these were 47.8% and 48.0%. In other words, all taken together, 4 of the 6 groups were very similar, with only the lowest U.S. group and, in particular, the highest Norwegian group, deviating (both in the same, low, direction).

3) "My parents have supported me in my cross-country skiing"

Table 3 a: Norway

			Question 7			Total
			3	4	5	
Group 1	Count		1	4	32	37
	% within group		2,7%	10,8%	86,5%	100,0%
2	Count		1	4	41	46
	% within group		2,2%	8,7%	89,1%	100,0%
3	Count		0	5	20	25
	% within group		0,0%	20,0%	80,0%	100,0%
Total		Count	2	13	93	108
		% within group	1,9%	12,0%	86,1%	100,0%

Percentage agree (12.0 %) and completely agree (86.1 %) = 98.1 % (bold script)

Table 3 b: USA

			Question 7				Total
			3	4	5	5	
Group	1	Count % within group	3 15,0%	4 20,0%	0 0,0%	13 65,0%	20 100,0%
	2	Count % within group	2 2,9%	7 10,3%	1 1,5%	58 85,3%	68 100,0%
	3	Count % within group	1 4,8%	3 14,3%	0 0,0%	17 81,0%	21 100,0%
Total		Count % within group	6 5,5%	14 12,8%	1 0,9%	88 80,7%	109 100,0%

Percentage agree and completely agree are combined in bold script for each group and for the total

Here the concurrence in both countries is nearly unanimous. In Norway, 98.1% of the respondents agree or completely agree, while in the United States the figure is 94.4%. In the performance group analysis, one deviation was found; the U.S. top group, where the figure was as low as 85.0%. All other groups score over 95%.

4) "My parents were driving me to most of the ski workouts"

Table 4 a: Norway

		Frequency	Valid Percent	Cumulative Percent
Valid	1	5	4,6	4,6
	2	3	2,8	7,4
	3	3	2,8	10,2
	4	21	19,4	29,6
	5	76	70,4	100,0
	Total	108	100,0	
Missing	System	1		
Total		109		

Percentage agree (19.4 %) and completely agree (70.4 %) = 89.8 % (bold script)

Table 4 b: USA

		Frequency	Valid Percent	Cumulative Percent
Valid	1	7	6,4	6,4
	2	15	13,8	20,2
	3	17	15,6	35,8
	4	3	2,8	38,5
	4	23	21,1	59,6
	5	44	40,4	100,0
	Total	109	100,0	

Percentage agree (23.9 %) and completely agree (40.4 %) = 64.3 % (bold script)

Nine of ten (89.8%) of the Norwegian skiers agreed or completely agreed that their parents had driven them to most workouts. The comparative data from U.S. showed 64.3%, a full 25.5 percentage points below Norway.

5) How long a distance from home were the cross-country ski trails you used after you started with regular cross-country training?

Table 5 a: Norway

		Frequency	Valid Percent	Cumulative Percent
Valid	< 1km	32	29,6	29,6
	1-5km	33	30,6	60,2
	6-10km	19	17,6	77,8
	11-20km	11	10,2	88,0
	> 20km	7	6,5	94,4
	Highly variable	6	5,6	100,0
	Total	108	100,0	
Missing System		1		
Total		109		

Table 5 b: USA

	Frequency	Valid Percent	Cumulative Percent
Valid < 1km	13	11,9	11,9
1-5km	14	12,8	24,8
6-10km	18	16,5	41,3
11-20km		22,0	63,3
> 20km	35	32,1	95,4
Highly variable	5	4,6	100,0
Total	109	100,0	

Among the Norwegian skiers, 29.6% had under 1 km. to the trails, while 60.2% had fewer than 5 km. This was dramatically different from the United States where only 11.9% had under 1 km. and 24.8% had fewer than 5 km. For distances over 5 km. and up to 10 km. the two countries were quite similar, with figures of 17.6% for Norway and 16.5% for the U.S.A. Finally, for distances to trails over 10 km. the national differences are, again, momentuous with only 16.7% of the Norwegian skiers having such a long transportation distance, while for the U.S. skiers the figure was 54.1%.

Little variation in this regard among the different performance groups was found in the United States. However, this was not the case for Norway, where fewer than half as many (16.0%) in Group 3 lived under 1 km. from the trails, as compared to Group 2 (34.8%), and Group 1 (32.4%). This variation among the Norwegian groups changed quickly and consequentially in the opposite direction with increased travel distance. Already at the next distance category (over 1, and up to 5 km.), Group 3 was up to 40.0%, while Group 2 was at a moderate 30.4%, and Group 1, a low 24.3%.

6) "My parents had big expectations for my cross-country ski performances"

Table 6 a: Norway

		Question 8					Total
		1	2	3	4	5	
Group 1	Count	10	10	10	6	1	37
	% within group	27,0%	27,0%	27,0%	16,2%	2,7%	100,0%
2	Count	8	11	22	4	1	46
	% within group	17,4%	23,9%	47,8%	8,7%	2,2%	100,0%
3	Count	1	5	19	0	0	25
	% within group	4,0%	20,0%	76,0%	0,0%	0,0%	100,0%
Total	Count	19	26	51	10	2	108
	% within group	17,6%	24,1%	47,2%	9,3%	1,9%	100,0%

Percentages in bold script for agree/completely agree, neither agree/nor disagree and disagree/completely disagree respectively are pair-wise combined

Table 6 b: USA

		Question 8						Total
		1	2	3	3	4	5	
Group 1	Count	3	2	9	0	3	3	20
	% within group	15,0%	10,0%	45,0%	0,0%	15,0%	15,0%	100,0%
2	Count	6	14	28	1	13	6	68
	% within group	8,8%	20,6%	41,2%	1,5%	19,1%	8,8%	100,0%
3	Count	2	3	3	0	10	1	19
	% within group	10,5%	15,8%	15,8%	0,0%	52,6%	5,3%	100,0%
Total	Count	11	19	40	1	26	10	107
	% within group	10,3%	17,8%	37,4%	0,9%	24,3%	9,3%	100,0%

Percentages in bold script for agree/completely agree, neither agree/nor disagree and disagree/completely disagree respectively are pair-wise combined

In Norway, only 11.2% of the skiers agreed or agreed completely with this statement, whereas in the United States, three times as many, or 33.1% concurred. Those disagreeing or completely disagreeing were as many as 41.7% in Norway, compared with only 28.1% in the U.S. That this question effected a wide spread of responses is underlined by the fact that as many as 47.2% of the Norwegian skiers and 38.3% of their U.S. counterparts neither agreed nor disagreed.

The great variability of response was reinforced when a performance group analysis was undertaken. On the Group 1 level, 18.9% in Norway agreed or completely agreed, while of Group 3, none (0.0%) did so. For the United States, the situation was converse; 30.0% in Group 1 agreed or completely agreed, while as many as 57.9% in Group 3 did so. For those who neither agreed nor disagreed, it was Group 3 that was the largest in Norway, with fully 76.0%, whereas in the United States Groups 1 and 2 predominated, with 45.0% and 42.7%, respectively.

7) Who had the main responsibility for you in childhood?

Table 7 a: Norway

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Both parents	101	92,7	94,4	94,4
	Mother	4	3,7	3,7	98,1
	Father	2	1,8	1,9	100,0
	Total	107	98,2	100,0	
Missing	System	2	1,8		
Total		109	100,0		

Percentages from the text are shown in the table in bold script

Table 7 b: USA

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Both parents	98	89,9	91,6	91,6
	Mother	9	8,3	8,4	100,0
	Total	107	98,2	100,0	
Missing	System	2	1,8		
Total		109	100,0		

Percentages from the text are shown in table in bold script

In Norway, 94.4% of the respondent skiers grew up with both parents. For those who did not, the mother had the main responsibility for 3.7 percentage points of the cases, while the father stood for 1.9. For the United States skiers the situation was not very different, with 91.6% growing up with both parents. In all the remaining 8.4%, it was the mother who had the responsibility for upbringing.

8) Which of the following categories describes the socioeconomic status of the household you were raised in as a child between 5 – 18 years of age?

Table 8 a: Norway

	Frequency	Valid Percent	Cumulative Percent
Valid Highest level	8	7,4	7,4
Upper middle level	31	28,7	36,1
Middle level	62	57,4	93,5
Lower middle level	7	6,5	100,0
Total	108	100,0	
Missing System	1		
Total	109		

Percentages from the text are shown in table in bold script

Table 8 b: USA

	Frequency	Valid Percent	Cumulative Percent
Valid Upper middle level	31	29,0	29,0
Middle level	63	58,9	87,9
Lower middle level	13	12,1	100,0
Total	107	100,0	
Missing System	2		
Total	109		

Percentages from the text are shown in the table in bold script

In Norway, 57.4% of the athletes placed themselves in the middle level, with 28.7% in the upper middle level. In the United States, the figures were strikingly similar; 58.9% and 29.0%. A growing-up period at the highest socio-economic level was found only among Norwegian skiers, who reported a proportion of 7.4%. The lower middle level, as well, is not extensively represented among the skiers of either country; 6.5% in Norway, and 12.1% in the United States. These latter figures still represent a clear difference between the nations. At the lowest level there are no skiers in either country reporting.

DISCUSSION

Parents as Role Models in the Socialization to Sport

1) Considerable time together with the family on skis

This study shows that significant amount of time spent with the family appears to be a foundation for shaping an identity and lifestyle leading to high performance levels in cross country skiing. For more than 9 of 10 top Norwegian cross country skiers, this was the family dynamic in the formative years. This represents a specific socialization process which supports the findings of Soberlak [40], Côté [12], and Bloom [5] and their characterization of the “sampling years” up until age 15. In the United States, that fewer than 3 of 4 of the skiers had a similar growing-up experience, can be an expression of cross country skiing being less of a cultural phenomenon than in Norway. This finding of more ski-specific family dynamics in Norway leads to a suggestion that this factor provides part of the explanation why Norway, despite its low population, is highly prominent in the sport. The large population and often favourable topography in the areas of the U.S. with reliable snow, has not engendered a similarly deep anchoring of skiing in the culture, and consequently, then, of parenting patterns reflecting this.

That, notwithstanding the less supportive U.S. context for cross country ski development, still nearly 3 of 4 of the best skiers of that country did grow up under similar family conditions as the best Norwegian skiers, indicates that the point of departure for parents interested in the skiing potential of their children could be formulated

as: *"If you wish your children to see how good they can become in cross country skiing, then you should be with them often on skis during their formative years."*

2) The competition background of parents in cross country skiing.

The proportion of parents with competition experience in cross country skiing is somewhat higher in the United States (48.6%) than in Norway (43.6%). The performance group analysis of the two countries exhibits one striking exception to the 42.2–50.0% range of five of the groupings; that of the Norwegian Group 1, at 35.1%. In this top group are found many of the world's best skiers. This suggests that specific parental ski background may not be as important for elite performance development in a country with a strong cultural tradition in the sport, as in a country where cross country skiing is a more peripheral, subcultural phenomenon, and where parents with such personal background become significant bearers of the subcultural tradition. However, though a 15 percentage point difference between the top groups in the two countries in parental cross country ski experience, may appear large, it should be noted that even in Norway more than one in three world class skiers were likely to have been positively affected by their competition-experienced parents. This contention gains support from the Breivik & Gilberg [6] study where 42.5% of their Norwegian world elite sample had competition background and nearly all of them in the sport that their offspring would later reach the top in.

3) Parental support

Parental engagement and support has in both countries been nearly maximal. This confirms the findings of the multitude of studies on this topic [5, 12, 17, 20, 21, 40, 47]. Attention should, nevertheless, be drawn to an element of difference in the between-group data. Contrary to the small differences between the Norwegian groups, the U.S. top group only evidenced an 85.0% figure of parental support whereas Group 2 and 3 showed 97.1% and 95.3%. A possible interpretation of this is that the commitment required to reach the very top level is such that parents question this within the broader material/cultural imperatives of American life. In Norway, a name in skiing is a name in the nation and can lead to post-career opportunities, while in the United States such expectations are more uncertain. However, a

critical view of the strong results in the present study raises the question whether the Norwegian and American cross country skiers interpreted the support issue similarly. The difference in frequency of skiing with the children would lead to an expectation that this should be reflected in the support figures. However, this factor could be outweighed by greater economic support or other factors in the United States.

4) Parental transport related to distance between home and ski-trails.

While 9 of 10 in Norway were driven by parents to most ski-training, this was the case for only 6 of 10 in the United States. Higher parental motivation could be a reason for the Norwegian figure. The structure of work could be another factor, whereby parental accessibility in Norway could be greater due to shorter working hours, with consequent greater matching between end of classes at school and the time of work-day finish. The very large difference between the two countries in the number of skiers living less than 1 km. from trails (Norway, 29.6%, and the U.S., 11.9%) would lead to an expectation that parental driving would be less prominent in Norway; -walking to training carrying skis, poles, and a backpack with extra clothing and ski waxes, would be feasible for this short distance. However, contrary to the relative commonness of such a situation, Norwegian parents still drove their skiing offspring more, perhaps more for reasons of psycho/social support, or simply to facilitate more ski-specific training. By driving even short distances, time could be saved for greater amounts of ski-training, compared with the general, more uncertain training benefits accruing from walking/carrying gear to and from the skiing-site.

A reason for lower parental transport support in the United States may be found in the lower age for gaining a driving license, generally at age 16, compared with 18 in Norway. The accessibility to vehicles may be yet another factor, where costs for acquiring and operating cars by young people are considerably lower in the United States. Organized collective transport (such as car-pooling) to trails, particularly those more distant from home, may also be more common in the U.S.

In general, it does not appear that transport costs have been a significant barrier to skier development in either country. However,

they may have blocked the recruitment to skiing for some who otherwise could have made their mark.

The question remains of the extent of alternative or organized group transport of skiers in the United States. Perhaps skiers who live further away from the trails ski less and compensate for this by more extensive alternative training? In this case, such an adaptation would lead in the direction of a lack of sufficient specific training to enable the athlete to reach the highest performance levels. A further consideration is that extensive, organized group transport would add yet another demand to the already voluminous requirements for planning and structure in the athlete's life. Consequences may be increased stress and a diminution of the energy resources in a sport which presumes a careful accumulation of all possible energy beyond the boundaries of that expended in training and competition. Individual, family-based transport opens for greater freedom and flexibility, with reduced routine stress for the athlete, although it is more costly both in money and time for parents. This is the daily, routinized toil that it appears parents must be motivated to tackle. An often unrecognized additional positive factor of family transport to training and competition is the motivation- and cohesion-building process of ski-related conversation during the drive.

The findings in the present investigation reveal clearly that the distance between home and ski-trails is a more powerful barrier for skiers in the United States and their parents, than it is in Norway, not only in the sense of the driving conundrum, but also in the distance *per se*. Not only do far more of the Norwegian skiers live close to the trails, but this factor is amplified by the direct relationship between performance level and home distance from trails, the top group having the shortest distance.

The general phenomenon of considerable transportation for Norwegian cross country skiers, however, contributes to putting an end to the myth that this diminishes the development of endurance and high performance capacity. On the contrary, quick, comfortable, predictable, and flexible transport to the ski-trails is advantageous in that it provides more time and energy for ski-specific training. Worthy of note is that only 3 athletes in the Norwegian sample were unsure in their response in this area, and could therefore have used alternative transport regularly.

The findings of the study give associations to established recognition that a long way to school or training site was the foun-

dition for the elite cross country skiers of old, as well as, for example, American World Cup champion, Bill Koch in more modern times; and moreover, for today's African distance runners' international dominance. The stories may well have been/are at least partially true. However, whether this is the optimal basis for the development of elite level performance today, is at best uncertain.

5) Parental expectations

Only approximately one in ten in Norway and three of ten in the USA agree with the statement that "my parents' expectations of my cross country ski performances were great". These responses are to a surprising degree diametrically opposite to what would be expected on the basis of the unequivocally large parental engagement and the support the parents have shown. Such parental behaviour can represent signals of a variety of meanings that can point in one or another direction. At the most extreme lies expectation-pressure, which in any case can be eliminated here. In the light of that 4 of 10 of the US skiers and nearly 5 of 10 in Norway are not able to take position on the question, this opens up for a number of interpretations.

The problematic response picture reveals considerable uncertainty as to which psychological mechanisms the self has been exposed to, as well as what meaning is actually assigned to the concept of "great expectations".

One immediate, near at hand, though simplified conclusion to the findings here, is that low or no parental expectations must be a significant success-factor in cross country skiing, something that is in contradiction to, but also in agreement with earlier research. On the other hand, such a conclusion would be more clearly in opposition to child rearing- as well as leadership-research on this dimension. In this regard the most startling finding here is the large proportion of skiers who are unsure of how to deal with this question. Are there some hidden taboos in operation, or is it a matter of unclear or simply different understandings of the concept of expectations? The taboo-rationale can, in Norway at least, be a reasonable interpretation in that a long and well publicized national debate has taken place on the issues of expectations-pressure, drop-out rates, and recruitment problems. A consequence of this may be that many skiers more or less consciously wish to distance themselves from the risk of being immersed in this turbulence. Many may be enticed to assume that the

expectation-area is more of a failure- than a success-factor, as was concluded in the Breivik & Gilberg [6] study. In this way it is not possible to avoid surmising that some respondents could be more or less conscious "victims" of expressing "politically correct" answers. Seen in the light of today's high knowledge- and education-level, this constitutes a steadily growing methodological problem in this type of research [4].

It is difficult to imagine that children and youth do not perceive the engagement of parents as an expression of expectations. The probability is large that parental engagement can end with substantial self-inflicted expectations which in the next round will be experienced as general pressure as such. In such a process the conjunction with expectations of parents is near. The question in the present investigation, however, concerned solely the degree of parental expectations.

Perhaps it would have been more appropriate to have limited the question to whether parents had expectations *per se* instead of asking if they were *great*? By examining more closely the response-percentage for those who disagreed, or completely disagreed, separately, the picture becomes more nuanced. Of the Norwegians, 24.1% disagreed with expectations having been great, while for the US skiers the percentage was 17.4. Nevertheless, this does not mean that expectations did not exist. Only 17.6% of the Norwegians and 8.3% in the US completely disagreed, and even these could have felt some, and up to a medium degree, of expectations from their parents.

Moving such an analysis into the response-arena of "agreed" and "completely agreed", then the 11.2% in Norway and the 33.1% in the US may be viewed as larger proportions than originally anticipated, particularly in the USA. The substantially greater experience of parental expectations among the US skiers could point to this as a negative factor in relation to success. This interpretation is near at hand in view of the performance differential between Norway and the USA. However, when account is taken of Norway as a world leader in cross country skiing, and that their highest level skiers were included in the study, then the findings for them should be the most telling. In this top group, nearly one in five felt great expectations from their parents, while no-one expressed this in the lowest performance group. The middle performance group figure fell approximately mid-way. Simultaneously, the top group showed the lowest degree of

uncertainty (27.0%), while the middle group figure was 47.8%, and the low group was fully 76.0% uncertain.

These results should speak loudly enough, but are, however, weakened by the internal state of affairs being directly opposite in the USA. Here there may lie tacit cultural differences that are problematic to unravel. A possible explanation could be that the generally larger proportion of great expectations in the US may be an expression of a hidden, even more elevated level of expectation; a level that may have tipped over to performance-impeding pressures. This would then be an illustration of the “no pain, no gain” processes embedded in the cultural history of American sport as expressed by Taylor [45] in his trenchant analysis of competitive cross country skiing in America.

6) Parental relations, main responsibility, and socio-economic status in the formative years.

More than 9 of 10 skiers in the study, both in Norway and the United States, grew up with both parents. This is illuminating in that the divorce rate in these two countries is high, and that child custody after divorce is rarely shared. What, then, does the divergent skier family-context mean?

The family in both countries has been viewed as an important condition for the child's experience of security and stability, and as decisive for positive growth and development. In Norway, the centrality of cross country skiing as a deep phenomenon of cultural tradition has meant that this element has also been a valued element of family life. As such, it has not needed any defense or justification; energy-demanding processes that subcultural patterns often require. That the findings of the present study are not unusual is corroborated by other investigations where 90 – 100% of athletes grew up with both parents present [6, 12, 17].

In the modern family, with increased pressures for gender equality and enhanced material resources, both parents tend to be occupationally active. This appears to be a necessary condition for a family economy at the middle class level, which, in turn, shapes the pre-condition for an active engagement in sport for both generations in the family [6, 12, 46]. Without exception, all skiers in the study illustrate this, growing up in families from the lower middle-class socio-economic level and up. In Norway, as many as 93.5% of the skiers came from families in the middle of the three sub-categories of

middle class, and upward. For the United States, this proportion was somewhat less; 87.9%; perhaps a modest contributory factor to the performance level difference between the two countries. In this regard, it should be noted that 7.4% of the Norwegian skiers came from an upper class background, whereas there were no American skiers from this socio-economic level. That no skiers in either country came from a lower class background was not unexpected; cross country skiing, with its material culture under constant development, requires considerable financial resources.

CONCLUSIONS

When more than 9 of 10 of the best cross country skiers in Norway and nearly 3 of 4 in the United States were **often together with the family on skis in childhood**, then this stands out as an important and basic condition for reaching the high levels of this sport. The action of the parents in this highly formative period of their children's life is a convincing expression of parental engagement and socio-cultural position. The difference in the national figures may, however, reveal part of the rationale for the general lack of U.S. international success in cross country skiing. The 19.2 percentage points lower figure for the United States skiers indicates a lesser parental involvement. On the other hand, a more general condition for parent influence is that more than 9 of 10 in both countries **grew up with both parents**. The strong family relations implied in an intact family setting may, then, be viewed as the foundation for the committed development process behind the high achieving skiers in the study.

Continued security and stability throughout the lengthy childhood phase appear to be decisive contributions facilitating the personality growth and development so necessary for success in this unusually complex Olympic sport. Part of this security and stability has found its source in the **skiing-families' socio-economic status** which has been sufficiently high to meet the requirements for costly ski-equipment and transport. Yearly model-changes in skis related to different techniques and snow conditions should be noted as a particular economic burden. Approximately 2 of 3 of the skiers in the study have grown up in medium category of the three levels of middle class used

in the investigation, with 1 of 3 in the upper middle class. Here there were no significant differences between the two countries.

The social and economic structure of the family of the successful skier confirms the findings of the broader study of the background of elite Swedish athletes by Carlsson [10].

The strongest confirmation of the importance of the parental role was found in the response to **“(m)y parents have supported me in my efforts in cross country skiing**. When virtually all the Norwegian skiers and 9 of 10 American skiers concurred, then this feature shows itself as one of essence. The parental role can hardly be more powerful in its contribution to facilitating optimal conditions for the development of high skiing achievements. However, a general perception, such as is generated by the questionnaire statement above, needs to be complemented by skier reference to concrete actions by parents. Other investigations in sport indicate that transportation to and from training and competition compose one of the most important parental support functions. In the present study, this is concretized in the response to the statement: **“My parents drove me to most training sessions”**. As many as 9 of 10 (89.8%) of the Norwegian skiers are in agreement, whereas the numbers in the United States fall to below 2 out of 3 (64.3%). This 25.5 percentage point difference in favour of Norway is further reinforced by that nearly three times as many Norwegian skiers as American, lived under 5 km from the ski trails. But this is not the entire story. In the categories of the longest distance of trails from home (more than 10 and 20 km.), the relationship is converse; more than three times as many U.S. as Norwegian skiers had these long distances to travel in order to ski-train. In addition, all Norwegian skiers were driven by their parents these long distances, while this was the case for only 1 of 4 American skiers. Here it is possible that in the United States parents in the ski-group shared driving tasks, providing a mixed group-situation where skier interaction could lead to positive anchoring effects in the sport, as an alternative to the bonding possibilities of family driving.

Parents as role- and culture-carriers of an achievement culture was mapped partially by the responses to the statement: **“One or both parents have been competitors in cross country skiing”**. A more specific performance-oriented query could hardly be posed. Close to half the respondent skiers in both countries answered affirmatively, confirming the weight of this contribution to shaping an identity of

striving, specifically for cross country skiing. The experience-based knowledge and insight of parents with racing background would not only have been of benefit to their family, but also to others in the sport with whom they unquestionably would have come into contact. It was, however, unexpected that the highest level group in Norway had the lowest proportion with such parents, with just over 1 in 3. Other factors, then, must be brought into the explanation for the extreme success that this group has achieved. In reference to the Breivik & Gilberg [6] study, their figures showed the Norwegian world elite group placed about midway between Group 1 (35.1%) and the overall figure (48.6%) for the Norwegian skiers in the present investigation. In other words, there appears to be a pattern whereby the very best in Norwegian sport are somewhat less likely than those close to the top, to have parents with competition background in their specific sport.

It could be expected that the sizeable parental engagement would be experienced as an expression of great parental expectations by the athletes. This, however, does not appear to be the case; the contrary is more evident. Only approximately 1 in 10 (11.2%) in Norway, and 1 in 3 (33.6%) of the U.S. skiers agreed with the statement: **"My parents' expectations of my cross country ski performances were high"**. However, the picture is not as clear as it seems in that nearly half (47.2%) of the Norwegian athletes, and close to 4 of 10 (38.3%) of the American skiers were not sure how to respond to this statement. Simultaneously, though, it is seen that among the Norwegians, it is Group 1 that by far displays the highest concurrence with the statement, at nearly 2 in 10 (18.9%), whereas no-one in Group 3 does. This suggests that for extreme performance, skier perception of high parental expectations may, in some cases, be part of the developmental foundation.

In the United States, the pattern is quite the opposite. The distribution of responses appears such that it leads to a suggestion that the concept of expectations may have been experienced as too complex for many. In any case, that 57.9% of Group 3 pointed to parental high expectations, while only 30.0% of Group 1 did, merits further investigation.

The results of the parents' status, role, and engagement are that they have in decisive terms contributed to the creation of what has been termed *"athlete families"*. The confirmation of this is not only the high level skiers in the study, but also the general sport- and ski-

specific involvement of siblings; not to speak of the foundation of athletic parents.

The total role of the family and its importance in the recruitment and development of the young appears decisive in the process of becoming an outstanding cross country ski competitor. Primary significance here in the present study, as in others referred to, is ascribed to the parents. It may well be that this is generally applicable to high level sport as such. Although the connection between family dynamics and the child's general life conditions as a foundation for the development of high athletic performance in the youth years, appears unmistakable, it must, nevertheless, be recognized that the family alone cannot fully facilitate the process to elite performance. For the tower of peak achievement, the enhancement of the expertise of sport-specific organizations and their coaches is needed.

Norway's international dominance by the generation of skiers under purview in the present study coincides with the recognition of the parental role and its significance, as here documented. The Norwegian parents have had, broadly viewed, a considerable greater involvement than those of the American skiers. This has been confirmed through the varied angles of approach taken in the study.

The broad consequences of the recognitions of the present study direct attention to the necessity of viewing sport as a result of societal contexts. More specifically, athletic performances may largely be seen as mirroring the total family condition and life situation, and as such can be a measuring rod for a society's policies directed to the family. With a well-organized and family-friendly political and economic system, a society will facilitate both broad athletic participation as well as performances at the very highest levels.

Although the present investigation corroborates the findings of other studies referred to and thus strengthens its generalizability concerning the parental role in sport, future inquiries in this realm could with advantage focus on yet other sports with a variety of hypothetical parental demands in order to delineate possible nuances of value in the parenting process of aspiring youngsters. An additional and complementary approach would be to extend the international comparative perspective to uncover further cultural underpinnings that may be of importance in the developmental voyage of ambitious young athletes.

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GENDER EFFECT ON PERCEIVED NEED SUPPORT FROM THE TEACHER AND PEERS IN PHYSICAL EDUCATION

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ABSTRACT

The purpose of the present study was to examine gender differences in perceptions of basic psychological needs support from the teacher and peers in physical education. The 659 Estonian secondary school students (310 boys and 349 girls; M age=13.57 years, $SD=0.62$) completed questionnaires assessing the perceptions of autonomy, competence, and relatedness need support from both the teacher and peers in physical education. Results of the independent samples t-tests revealed that boys scored significantly higher than girls on perceptions of all three need support from the teacher, whereas girls scored significantly higher than boys on perceptions of all three need support from peers. Results are discussed in relation with practical implications to physical education teachers in order to facilitate the satisfaction of the basic psychological needs for both boys and girls more efficiently.

Key words: adolescents; psychological needs for autonomy, competence, and relatedness; self-determination theory, significant others

INTRODUCTION

According to self-determination theory (SDT), introduced by Deci and Ryan [4], overall healthy functioning as well as self-determined learning in school is dependent on the satisfaction of three basic

psychological needs for autonomy, competence, and relatedness. There are few studies in physical education (PE) that have examined the effect of basic psychological need-supporting context on students' needs satisfaction and motivation [10, 12]. Standage and colleagues [12], for example, showed that multifaceted need-supporting behaviour from the teacher encompassing perception of autonomy, competence, and relatedness support positively predicted students' self-determined motivation in PE mediated by perceived need satisfaction.

There is evidence in literature dealing with gender differences in PE that teachers tend to interact with students differently. Davis's [3] review of literature suggests that PE teachers interact verbally more often with boys than girls. For example, past research has shown that boys perceived their PE teachers asking them questions [2, 6] and providing them with positive general feedback (i.e., praise and encouragement) more often compared to girls [9]. Moreover, studies have documented that there is not always congruence between what a teacher actually says and how students perceive and interpret the information [7]. Therefore, it is necessary to investigate how students perceive and interpret various aspects of student-teacher interaction in PE. It is not clear so far, however, is there any gender differences in perceptions of the three basic psychological needs support from the PE teacher.

According to Sage and Kindermann [11], the interaction between peers in classroom may have proportionally even greater influence on children's different psychological aspects of participation in PE than those of teachers because teachers' influence is considered to be more distal. Bearing this in mind, one may argue that perception of autonomy, competence, and relatedness support from the teacher is not the sole source of basic psychological needs support for students in PE. Interestingly, however, there is no evidence regarding the effect of gender on the perceptions of autonomy, competence, and relatedness needs support from peers in PE.

The aim of the present study was to investigate gender differences in perceived psychological needs support from both the teacher and peers in PE. According to previous research [2, 6, 9], it was hypothesized that boys exhibit higher perceptions of autonomy, competence, and relatedness needs support from the PE teacher than girls. Regarding the hypothesis on the existence of gender differences in perceptions of autonomy, competence, and relatedness needs

support from peers in PE, no a priori hypothesis was proposed because of any previous findings in this specific domain.

METHODS

Subjects

The participants were 659 (310 boys and 349 girls; M age=13.57 years, $SD=0.62$) secondary school students from a town located in southeast of Estonia. 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 were returned. Students were administered with the questionnaires that took approximately 10 min to complete in their 'home room' during the regular school day. Students were assured about the confidentiality of their answers.

Measures

Perceived Psychological Need Support from the Teacher in PE. To assess the degree to which the students perceived the PE teacher to support their needs for autonomy, competence, and relatedness in PE, 15-item need support scale devised by Standage and colleagues [12] was used. All items were preceded by the same stem, "In this PE class...", and students responded on 7-point scale ranging from 1 (strongly disagree) to 7 (strongly agree). An example items from the scale are as follows: "...I feel that the teacher provides me with choices and options" (autonomy support; 6 items), "...the teacher makes me feel like I am good at PE" (competence support; 4 items), and "...the teacher encourages me to work with others in class activities" (relatedness support; 5 items). In the present study, the Cronbach's alphas for autonomy support, competence support, and relatedness support subscales were 0.86, 0.67, and 0.87, respectively. Furthermore, CFA supported the proposed three-factor structure of the scale. The goodness of fit test parameters were: $\chi^2(87)=263.75$, $p=0.001$, χ^2/df ratio=3.03, CFI=0.94, NNFI=0.92, RMSEA=0.057, 90% confidence interval (CI_{90}) for RMSEA range=0.049 to 0.065.

Perceived Psychological Need Support from Peers in PE. To assess the degree to which students perceived peers to support their needs for autonomy, competence, and relatedness need in PE, items derived from the 15-item need support scale was used that was originally designed to assess perceptions of the need support from the teacher in PE [12]. The original items were modified by changing the 'teacher' to 'peers' as the salient referent. All items again were preceded by the same stem, "In this PE class...", and students responded on 7-point scale ranging from 1 (strongly disagree) to 7 (strongly agree). An example items from the scale are as follows: "...I feel that the peers provide me with choices and options" (autonomy support; 6 items), "...the peers make me feel like I am good at PE" (competence support; 4 items), and "...the peers encourage me to work with others in class activities" (relatedness support; 5 items). In the present study, the Cronbach's alphas for autonomy support, competence support, and relatedness support subscales were .87, .84, and .88, respectively. Results of the CFA yielded acceptable fit indices: $\chi^2(87)=244.91$, $p=0.001$, χ^2/df ratio=2.82, CFI=0.95, NNFI=0.93, RMSEA=0.054, CI₉₀ for RMSEA range=0.046 to 0.062.

Data Analysis

Independent-samples T-tests were used to investigate gender differences on perceptions of autonomy, competence, and relatedness needs support from both the PE teacher and peers.

RESULTS

Independent-samples T-tests revealed that there were significant gender differences on all study variables (see Figure 1). Results indicated that while boys scored significantly higher on perceptions of autonomy, competence, and relatedness needs support from the PE teacher, the girls scored significantly higher on perceptions of autonomy, competence, and relatedness needs support from peers. Specifically, boys perceived significantly more that their PE teacher provided them with autonomy support ($M_{\text{boys}}=4.28\pm1.32$ vs $M_{\text{girls}}=3.98\pm1.23$, $p<0.01$), competence support ($M_{\text{boys}}=5.27\pm1.34$ vs $M_{\text{girls}}=4.99\pm1.24$, $p<0.01$), and relatedness support ($M_{\text{boys}}=4.62\pm1.38$ vs $M_{\text{girls}}=4.38\pm1.39$, $p<0.05$), whereas girls perceived significantly more

that their peers provided them with autonomy support ($M_{\text{girls}}=4.76\pm1.27$ vs $M_{\text{boys}}=4.18\pm1.37$, $p<0.001$), competence support ($M_{\text{girls}}=4.77\pm1.35$ vs $M_{\text{boys}}=4.30\pm1.50$, $p<0.001$), and relatedness support ($M_{\text{girls}}=5.33\pm1.28$ vs $M_{\text{boys}}=4.53\pm1.39$, $p<0.001$).

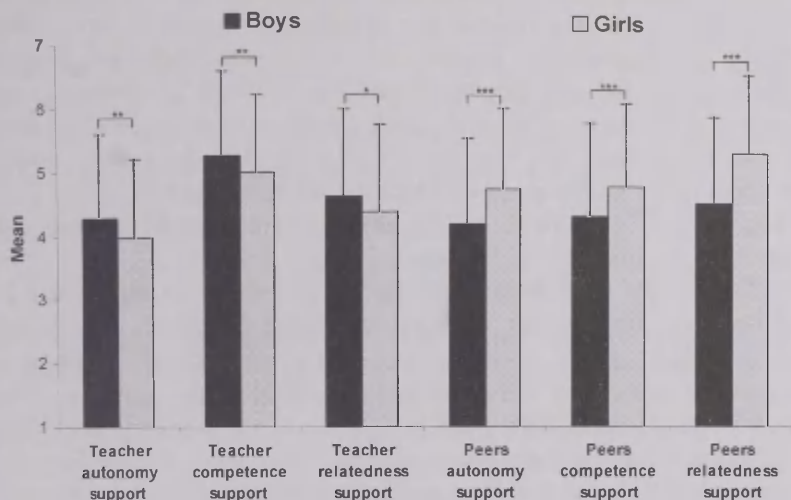


Figure 1. Gender differences for all study variables. * $p<0.05$, ** $p<0.01$; *** $p<0.001$.

DISCUSSION

The aim of the present study was to investigate the effect of gender on perceptions of basic psychological needs support from both the teacher and peers in PE. Overall, the results showed that boys scored significantly higher than girls on perceptions of all three need support from the teacher, whereas girls scored significantly higher than boys on perceptions of all three need support from peers.

The results of this study showed that boys perceived significantly higher their PE teacher's autonomy-, competence-, and relatedness-supportive behaviour than girls. In general, this is consistent with previous studies indicated that PE teachers interact more often with boys than girls [2, 3, 6, 9]. Specifically, results of the present study suggest that PE teachers provide boys with more choices and options in PE (i.e., one of the autonomy-supportive behaviours). Also, results

suggest that PE teachers respect boys and interact more with them in a friendly way (i.e., relatedness-supportive behaviour). Finally, results revealed that PE teachers provide boys more often with positive statements allowing them to know that they are good at PE (i.e., competence-supportive behaviour). As regards to practical implications for practicing PE teachers, in order to enhance the perceptions of teacher's autonomy, competence, and relatedness needs support among girls, teachers should interact with them more frequently and involve them more often into the decision making process; let them know more often that they are doing well; and show more respect towards them. In doing so PE teachers are able better to satisfy girls' basic psychological needs in PE, which, in turn, would enhance self-determined learning [5].

The unique contribution of the present study to the extant PE literature is the finding revealed that girls perceived significantly higher their peers' autonomy-, competence-, and relatedness-supportive behaviour compared to boys. Specifically, girls perceived their peers (i) to be more friendly and respectful towards them during PE classes (i.e., relatedness-supportive behaviour); (ii) letting them more often to know that they are good at PE; and (iii) allowing them more often to decide about the strategies of games. These results suggest that girls tend to hold together and support each other in PE stronger than boys. In general, such gender difference is compatible with the social psychology theories documenting that females are more influenceable, especially by their peers. In line with social psychology theories, Baumeister and Kristin [1], for example, have also demonstrated that females are oriented more toward dyadic close relationships, whereas males are oriented toward a larger group. As regards to practical implications for practicing PE teachers, in order to enhance the perceptions of psychological needs support from peers among boys, teachers should create opportunities where students are able to interact more often and more closely with each other. According to the results of the study by Morgan and Carpenter [8], PE teachers should set up cooperative tasks in small groups more often. While doing so, PE teachers should guide students so that they will interact with each other in a basic psychological need-supportive way, which, in turn, should result in a students' learning that is more self-determined [5].

Although the present study provided some interesting and unique information about the effect of gender on basic psychological needs

support from both the teacher and peers in PE among secondary school students in Estonia, the caution about the generalizability of the present findings should be taken. That is, the present sample does not represent the entire population of the secondary school students.

In summary, teacher should consider that boys and girls may vary in their perceptions of psychological needs supportive behaviours form the teacher and peers in PE. This knowledge should help practicing PE teachers to interact with their students more efficiently in order to facilitate the satisfaction of the basic psychological needs in PE, which, in turn, should result in self-determined learning.

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INSTRUCTION TO AUTHORS

Acta Kinesiologiae Universitatis Tartuensis is a multidisciplinary (publishing papers on diverse subjects from sports and exercise sciences) annual publication.

Manuscripts are accepted for consideration with the understanding that their contents not been published elsewhere. Manuscripts are read through by the editor and by two reviewers in blind review process, which takes 8–10 weeks.

Manuscripts are to be submitted in English. Submit three clear copies of the manuscripts to the editor. Maximum volume of text is 10 pages, maximum total volume is 15 pages. Type the manuscripts double-spaced on one side of A4 paper with margin of 3 cm on the left side.

The manuscripts should be arranged as following

1. Title page

Title of the article in capital letters, names of authors, authors institution, name and address of the principal author, up to 5 key words. For blind review, a second title page is needed that contains only the title.

2. Abstract (up to 200 words, separate sheets).

3. Text

The text should contain the following sections: Introduction, Materials and Methods, Results, Discussion, References, Acknowledgements if any. Tables and Figures should be presented on separate sheets. Figures should be professional in appearance and have clean, crisp lines. Identify each Figure by marking lightly on the back, indicating. Figure number, top side and abbreviated title of manuscripts. Legends for the Figures should be submitted on a separate sheet. Tables should be double-spaced on separate sheet and include a brief title. The SI units should be used in presenting results.

Each citation in the text must be noted by number in parenthesis and must appear in the reference list as well. Each entry in the

reference list must be double-spaced, arranged alphabetically and numbered serially by author with only reference per number. Non-english papers should be cited in the original language.

Entries in the reference list should be as follows:

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