DISSERTATIONES
KINESIOLOGIAE
UNIVERSITATIS
TARTUENSIS
36

HELENA LIIV

Anthropometry, body composition and aerobic capacity in elite DanceSport athletes compared with ballet and contemporary dancers

DISSERTATIONES KINESIOLOGIAE UNIVERSITATIS TARTUENSIS

36

DISSERTATIONES KINESIOLOGIAE UNIVERSITATIS TARTUENSIS
36

HELENA LIIV

Anthropometry, body composition and aerobic capacity in elite DanceSport athletes compared with ballet and contemporary dancers

UNIVERSITY OF TARTU
PRESS
1632

Institute of Sport Pedagogy and Coaching Sciences, Faculty of Exercise and Sport Sciences, University of Tartu, Tartu, Estonia

Dissertation was accepted for the commencement of the Degree of Doctor of Philosophy in Exercise and Sport Sciences on February 19, 2014 by the Council of the Faculty of Exercise and Sport Sciences, University of Tartu, Tartu, Estonia.

Supervisors: Professor Jaak Jürimäe, PhD, University of Tartu, Tartu, Estonia

Senior Lecturer Jarek Mäestu, PhD, University of Tartu, Tartu, Estonia

Professor emeritus Toivo Jürimäe, PhD, University of Tartu, Tartu, Estonia

Opponent: Professor Yiannis Koutedakis, PhD, University of Thessaly, Greece and Visiting Prof. University of Wolverhampton, UK

Commencement: Senate Room of the University of Tartu, Ülikooli St. 18, Tartu on April 11, 2014 at 12.15.

Publication of this thesis has been granted by the Faculty of Exercise and Sport Sciences, University of Tartu and the Doctoral School of Behavioural, Social and Health Sciences created under the auspices of European Social Fund.

European Union
European Social Fund

Investing in your future

ISSN 1406–1058
ISBN 978–9949–32–508–5 (print)
ISBN 978–9949–32–509–2 (pdf)

University of Tartu Press
www.tyk.ee

CONTENTS

ABBREVIATIONS

ANOVA	analysis of variance
AT	anaerobic threshold
BMI	body mass index
Body fat (%)	body fat percent
DXA	dual-energy x-ray absorptiometry
LA	blood lactate concentration
SD	standard deviation
VO_{2max}	maximal oxygen consumption

LIST OF ORIGINAL PUBLICATIONS

I **Liiv, H., Wyon, M., Jürimäe, T., Purge, P., Saar, M., Mäestu, J., Jürimäe, J.** Anthropometry and somatotypes of competitive DanceSport participants: A comparison of three different styles. *HOMO – Journal of Comparative Human Biology*. 2013. http://dx.doi.org/10.1016/j.jchb.2013.09.003.

II **Liiv, H., Jürimäe, T., Mäestu, J., Purge, P., Hannus, A., Jürimäe, J.** Physiological characteristics of elite dancers of different dance styles. *European Journal of Sport Science*. 2014; 14: S429–S436.

III **Liiv, H., Wyon, M., Jürimäe, T., Saar, M., Mäestu, J., Jürimäe, J.** Anthropometry, somatotypes and aerobic power in ballet, contemporary dance and DanceSport. *Medical Problems of Performing Artists*. 2013; 28: 207–211.

In Papers I and II, Helena Liiv had primary responsibility for protocol development, subjects' screening, performing measurements, preliminary and final data analyses, and writing of the manuscripts.

In Paper III, Helena Liiv had primary responsibility for preliminary and final data analyses, and writing of the manuscript. She also had primary responsibility for the screening and performing measurements of the DanceSport participants.

1. INTRODUCTION

DanceSport is a set of partner dances that has emerged from ballroom dance. DanceSport is the physical activity that combines sport and dance, and allows the participants to improve physical fitness and mental well-being, to form social relationships and to obtain results in competition at all levels (WDSF DanceSport for All, 2012). Competitive DanceSport in a wide variety of dance styles and forms is practiced within internationally recognized and organized competition structure of World DanceSport Federation (WDSF; WDSF DanceSport for All, 2012).

DanceSport has three disciplines: Standard Dances, Latin American Dances and Ten Dance. DanceSport consists of 10 different dances each with a specific character and tempo. The five Latin dances are Samba, Cha-Cha-Cha, Rumba, Paso Doble and Jive. The five Standard Dances are Waltz, Tango, Viennese Waltz, Slow Foxtrot and Quickstep. Standard Dances are more formal than their Latin counterparts – they are generally danced in a closed position of the partners. In closed position man and lady stand facing each other with light contact, arms are raised and connected. While Latin and Standard dances are two stand-alone disciplines, with competitions generally held per discipline, they are combined in Ten Dance, where couples perform all 10 dances (WDSF DanceSport for All, 2012). DanceSport belongs to aesthetic sports where the focus is on the artistic qualities or beauty of the performance and where success is often influenced by subjective opinions (Langdon, 2012). Therefore, dancers face the difficult task of combining aesthetic and physical component of the performance. Dancers have been referred as "performing" (Koutedakis & Jamurtas, 2004) and/or "aesthetic" (Wyon et al., 2007) athletes, who remain subject to the same unyielding physical laws as other athletes (Angioi, 2009).

Typical DanceSport competition lasts throughout the day for approximately 10 h and for a number of rounds before reaching the final dance round. During the final, athletes may have to dance up to all five dances in their discipline (each lasting maximum 2 min with a 15–20 s break between dances), being able to cope with the physical demands whilst making it appear effortless (Bria et al., 2011). During competition dancers are judged both on expressiveness and on physical abilities. For optimal performance, dancers must be experts in the aesthetic and technical sides of the art, psychologically prepared to handle the stress of critical situations, free from injury and they must also be physically fit (Koutedakis & Sharp, 2004). Dance training is a long process of physical, intellectual, and psychological preparation through physical exercise, often beginning in early childhood and continuing until retirement (Allen & Wyon, 2008).

DanceSport is an aesthetic sport where the body shape of the dancer is related to the choreography and the subsequent performance, and may influence the competition results. Just as the term sport covers a wide variety of different disciplines, dance is an umbrella term that includes diverse genres. Therefore, data obtained from one dance style may not be applicable to other dance genres. Different dance styles have different training and performance regimens. To our best of knowledge, there is a lack of studies in the field of DanceSport which have described specific anthropometric and body composition parameters that could be beneficial for the performance. In aesthetical sport such as DanceSport, anthropometrical characteristics are not only important for technical but also from aesthetical point of view. There are very limited published anthropometric data and there is no data about somatotypes of DanceSport athletes. It can only be presumed that different dance styles demand different posture and anthropometrical characteristics. In Standard dances, wide movement and a big dance hold (distance between partners heads and arms is relatively big without losing contact in abdominal area at the same time) is required, while Latin dances are faster and more energetic. It could also be hypothesized that a taller body and longer arms are advantageous in Standard dances, whilst a relatively shorter and accordingly faster body is helping to achieve better results in Latin dances.

It has been suggested that dancers could benefit from good aerobic capacity (Koutedakis et al., 2007). In the field of dance science, there are also very few studies related to aerobic capacity on DanceSport athletes (Blanksby & Reidy, 1988; Bria et al., 2011; Jensen et al., 2002). Previous studies have had small numbers of participants and to our best of knowledge, there are no studies performed on Ten Dance participants. Also, there is lack of comparison with other dance styles and no comparison between other aesthetic sports like gymnastics (McCabe et al., 2013). The present research has studied anthropometry, body composition and aerobic capacity in DanceSport athletes of three styles, and also compares anthropometry, body composition and aerobic capacity of DanceSport athletes with performers of other dance styles like classical ballet and contemporary dance.

2. REVIEW OF THE LITERATURE

2.1. Anthropometry and body composition characteristics in DanceSport athletes

DanceSport is an aesthetic sport where competition results depend on the beauty of the performance. Body image and anthropometrical parameters are important from the perspective of both technical as well as aesthetic purposes. Therefore, anthropometrical parameters, body shape and body composition are important parameters to influence the overall outcome of the performance and competition.

The identification of the physical attributes that may contribute to success in sport has long interested sport scientists and coaches (Carter et al., 2005).This is especially important in aesthetic sports like gymnastics and figure skating (Bloom, 1985; Bompa, 1985; Franks & Goodman, 1986; Malina, 1994; Monsma & Malina, 2005). To compare the body shape of the athletes and its effect on competition results, athletes' somatotypes has been calculated and used. The somatotype is a convenient shorthand description of overall body physique in terms of shape and composition independent of body size (Carter & Heath, 1990). It combines an appraisal of components – endomorphy or relative adiposity, mesomorphy or relative musculoskeletal robustness, and ectomorphy or relative linearity – into a three-number rating (Carter & Heath, 1990). Somatotyping has been used in talent identification for particular sports such as gymnastics, rowing, basketball, martial arts, swimming, netball and figure skating etc (Carter et al., 2005; Gualdi-Russo & Graziani, 1993; Hopper, 1997; Jürimäe, et al., 2005; Monsma & Malina, 2004). Calculating somatotype is a universal method that can be used to compare different sports and dance styles. Anthropometry in dance and aesthetic sports has been shown to play an important role in talent identification and performance criteria. Functional adaptation due to different training regimens may be responsible for the determination of some anthropometric (Del Balso & Cafarelli, 2007) and physiological (William et al., 2000) changes.

There is relatively little known about DanceSport anthropometrical parameters, body composition, somatotypes and how these factors contribute to the efficiency of dancers. Previous studies have reported body height and body mass values of DanceSport dancers in quite a broad range (Table 1). Height of female dancers ranged from 1.60–1.67 m and of male dancers from 1.75–1.80 m (Blanksby & Reidy, 1988; Bria et al., 2011; Jensen et al., 2002). Body mass of female dancers ranged from 49–58 kg and of male dancers from 61–69 kg (Blanksby & Reidy, 1988; Bria et al., 2011; Jensen et al., 2002).

Table 1. Mean (±SD) anthropometrical characteristics in DanceSport athletes participating in different dance styles

Reference	Dance style	Number of participants		Height (cm)		Body mass (kg)		Body fat (%)		Fat free mass (kg)	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Blanksby & Reidy, 1988	Standard	5	5	176.8±6.3	165.4±4.2	60.5±5.6	57.7±5.5	10.3±1.0	20.8±3.0	54.3±5.1	45.6±3.4
	Latin	5	5								
Bria et al., 2011	Standard	6	6	175.8±6.6	162.5±4.5	69.1±5.8	52.9±7.3	11.6±3.0	17.1±1.8	60.7±4.1	44.1±5.0
	Latin	6	6	174.5±5.0	159.8±3.0	66.8±4.7	49.1±2.7	9.4±3.5	14.1±5.5	46.9±14	30.9±10.8
Jensen et al., 2002	Standard	4	4	180.0±5.0	167.0±5.0	68.8±6.9	56.5±4.2	12.1±3.4	21.6±4.7		
	Latin	4	4								
Klonova et al., 2011	Standard	15	15	176.8	165.4	66.4	54.0				

In the field of dance, leanness is often seen as a prerequisite. Yannakoulia et al. (2000) have stated that body composition has an influence on dance performance because the optimal body composition is necessary for both the physiological needs of a healthy body and the esthetic goal of thinness. Many authors have been concerned about the low body fat percentage of female ballet dancers (Hamilton et al., 1988; Twitchett et al., 2010) as this might increase the risk of injury and delayed healing (Twitchett et al., 2008). In DanceSport, previous studies have only reported body fat percentages of dancers. Male and female DanceSport athletes' body fat percentage (Table 1) ranged from 9.4–12.1% and 14.1–21.6%, respectively (Blanksby & Reidy, 1988; Bria et al., 2011; Jensen et al., 2002).

In conclusion, previous research has mainly reported only height, body mass and BMI of DanceSport athletes, while investigations on DanceSport athlete's somatotype or anthropometrical parameters and its influence to the DanceSport performance or competition results is lacking in the literature.

2.2. Aerobic capacity and competition simulation in DanceSport athletes

Competitive ballroom dancing is a vigorous type physical activity requiring the cardiovascular system to work at levels which demand high energy expenditure to match high physiological strain during competitions (Blanksby & Reidy, 1988; Bria et al., 2011). Previous studies have demonstrated that the cardiovascular system is equally stressed during Standard and Latin American sequences for both male and female athletes (Blanksby & Reidy, 1988; Bria et al., 2011). It has been argued that the physical demands placed on dancers from current choreography make their physical fitness level as important as their skill development (Redding & Wyon, 2003). Latest research has shown that maximal oxygen consumption (VO_{2max}) of elite DanceSport athletes for male and female dancers is on average 58.3–60.9 $ml \cdot min^{-1} \cdot kg^{-1}$ and 46.3–53.7 $ml \cdot min^{-1} \cdot kg^{-1}$, respectively (Bria et al., 2011; Jensen et al., 2002; Klonova et al., 2011), while the highest values for blood lactate concentration after the competition have been found around 9.6 $mmol \cdot l^{-1}$and 8.9 $mmol \cdot l^{-1}$ for male and female dancers, respectively (Klonova et al., 2011) (Table 2). Furthermore, DanceSport athletes appear to be performing at relatively high energy-demands (both aerobic and anaerobic) during their competitive dance routines (Bria et al., 2011). Analyzing HR values during a one round competition simulation, Bria et al. (2011) found that in Latin American dances, the mean heart rate was higher than observed during a Standard sequence.

Table 2. Mean (±SD) aerobic capacity characteristics in DanceSport athletes participating in different dance styles

Reference	Dance style	Number of participants		VO_{2max} (ml.kg $^{-1}$ min $^{-1}$)		VO_2 during dance (ml.kg $^{-1}$ min $^{-1}$)		HR (% HR_{max}) during dance (beats.min^{-1})		Blood lactate after dance (mmol.l^{-1})	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Blanksby & Reidy, 1988	Standard	5	5	52.5±5.2	42.0±4.6	42.8±5.7	34.7±3.8	86.0±5.0	88.0±6.0		
	Latin	5	5			42.8±6.9	36.1±4.1	85.0±7.0	91.0±6.0		
Bria et al., 2011	Standard	6	6	60.9±6.0	53.7±5.0	45.8±6.0	38.0±8.5	91.1±3.5	90.7±5.2	6.5±2.1	6.9±2.6
	Latin	6	6	59.2±7.0	52.3±5.0	47.8±7.2	39.7±8.0	94.2±1.5	95.5±1.5	8.0±2.1	6.0±2.5
Jensen et al., 2002	Standard	4	4	58.3±5.7	46.7±6.0					6.5	
	Latin	4	4							9.7	
Klonova et al., 2011	Standard	15	15	60.4	46.3					9.6	8.9

Typical DanceSport competition lasts throughout the day for approximately 10 h and for number of dance rounds before reaching the final dance round. During the final round, athletes may have to dance up to all five dances in their discipline (each lasting maximum two minutes with a 15 to 20 s break between dances), being able to take the exertion while making it appear effortless (Bria, et al., 2011). However, to our best knowledge, there are no studies that have investigated the physiological response of male and female dancers throughout the whole one day competition to characterize the response of aerobic and anaerobic capacity values of dance couples of different styles. Previous studies consisting of competition simulations have used only one round of five dances which might not be adequate for investigating aerobic and anaerobic physiological strain of dancers relative to competitive stress (Blanksby & Reidy, 1988; Bria et al., 2011). Moreover, there seems no research been done amongst Ten Dance dancers, where five Standard and five Latin American dances are danced during the competition. To date, the comparison of aerobic and anaerobic capacity values during these three dance style competition simulation is also absent.

In conclusion, because of the demanding competition performance, competitive ballroom dancing is a vigorous physical exercise requiring high energy expenditure to match high physiological strain during competitions. However previous research so far has reported only Standard and Latin American dancers VO_{2max} values, average HR during one round competition and blood lactate values after one round competition simulation (Blanksby & Reidy, 1988; Bria et al., 2011; Jensen et al., 2002).

2.3. Differences in anthropometry, body composition and aerobic capacity between DanceSport, contemporary dance and ballet dancers

Classical ballet is a traditional, formal style performance dance, which started as a performance art in the French courts in the 16th and 17th centuries. Contemporary dance emerged at the beginning of the 20th century as a breakaway from the rigid constraints of classical ballet (Angioi et al., 2009). DanceSport is defined as partner dancing between a man and a woman combining as a couple. It has developed from court ballroom dances performed by couples. Dance genres differ from each other like sports disciplines. Different dance genres have different training regimes, aesthetic values and performance regimes. This generally may influence the physical abilities and body shapes of dancers.

It has been suggested that functional adaptation due to different training regimens may be responsible for the determination of some anthropometric (Del Balso & Cafarelli, 2007) and physiological changes (William et al., 2000). The number of hours per day and the number of days per week that a specific physical activity is performed may result in systematic changes in body composition (Bandyopadhyay, 2007). Hamilton, on the other hand, stated that "it is unclear whether ballet selects the perfect body, creates it, or makes both" (Hamilton et al., 1997).

The majority of previous studies have focused on one specific dance style dancers like ballet, contemporary dance or DanceSport, while the comparison of anthropometric variables, somatotypes and aerobic capacity between classical ballet dancers, contemporary dance dancers and DanceSport athletes is lacking in the literature.

It has been suggested that ballet, contemporary and DanceSport dancers performance would benefit from a good aerobic capacity (Allen & Wyon, 2008; Bria et al., 2011; Koutedakis et al., 2007) and that ballet and contemporary dancers performance benefits from physiological capabilities such as muscular strength and power (Brown et al., 2007; Koutedakis et al., 2007). Previous studies demonstrate that male and female DanceSport athletes present relatively high aerobic and anaerobic capacity values compared to ballet (Cohen et al., 1982; Oreb et al., 2006; Schantz & Astrand, 1984; Wyon et al., 2007) and contemporary dance dancers (Chmelar et al., 1988).

Very few published data exist on the somatotypes of dancers (Dolgener et al., 1980) but anthropometrical parameters such as height and body mass, are relatively well studied (Angioi et al., 2009; Bria et al., 2011; Coutts et al., 2006; Silva & Bonorino, 2008) and it has been found that body composition is influencing dance performance (Angioi et al., 2009). Dance science literature has been concerned about the female ballet dancers low body fat percentage (Hamilton et al., 1988; Twitchett et al., 2010) as it can increase the risk of injury and delayed healing (Twitchett et al., 2008). Based on previous studies, the body fat percentages of DanceSport athletes are similar compared with professional ballet and contemporary dancers (Angioi et al., 2009; Guidetti et al., 2007).

In conclusion, it might be suggested that there is probably no difference in VO_{2max} between ballet and contemporary dance students (Dahlstrom et al., 1996). Based on previous research, (Angioi et al., 2009; Blanksby and Reidy 1988; Bria et al., 2011; Chmelar et al., 1988; Cohen et al., 1982; Jensen et al., 2002; Klonova et al., 2011; Oreb et al., 2006; Schantz & Astrand, 1984; Wyon et al., 2007) that have also reported VO_{2max} values, we may hypothesize that DanceSport athletes probably have higher aerobic capacity compared with ballet dancers and contemporary dancers. However, successful ballet dancers have been found to be taller and leaner than contemporary dancers, although those differences were not significant (Dolgener et al., 1980).

3. AIM AND THE PURPOSES OF THE STUDY

General aim of the present study was to investigate international level DanceSport athlete's anthropometry, body composition and aerobic capacity in relation to the gender, dance style (Standard Dance, Latin American Dance and Ten Dance), international ranking and other dance genre (classical ballet and contemporary dance).

According to the general aim, the specific aims of the present study were to:

1. investigate whether there are any differences in anthropometric parameters, somatotyping and body composition characteristics between different DanceSport styles (Standard dance, Latin American dance and Ten Dance), and whether anthropometric parameters, somatotyping and body composition characteristics relate to international ranking;
2. investigate the aerobic capacity of the international level DanceSport athletes in laboratory settings and during typical competition simulation, in relation to gender, dance style (Standard dance, Latin American dance and Ten Dance) and international ranking;
3. compare anthropometry, somatotype, body composition and aerobic capacity values between DanceSport, classical ballet and contemporary dance dancers.

In this study we hypothesized that:

1) different dance styles favor different anthropometric and somatotype profile;
2) aerobic capacity values are related to competitive ranking in elite DanceSport athletes and competing in various dance styles requires different physical effort;
3) DanceSport athletes have better aerobic capacity compared with ballet and contemporary dancers and ballet dancers have lowest body fat percentage and BMI value.

4. METHODS

4.1. Participants

Two hundred and eighty six dancers from three dance genres took part in the study; 60 DanceSport dancers (30 male, 30 female), 89 ballet dancers (33 male, 56 female) and 137 contemporary dancers (28 male, 109 female) (Table 3). All participants originated from Europe. All participants were healthy and free of injuries. This study was approved by the Medical Ethics Committee of the University of Tartu, Tartu, Estonia; and the Research Ethics Committee of the University of Wolverhampton, Wolverhampton, UK. All participants signed an informed consent prior to testing.

4.1.1. DanceSport participants

A total of 30 top class DanceSport couples (12 Standard, 7 Latin American and 11 Ten Dance) volunteered to participate in the study. All DanceSport athletes were dancing couples who were competing at the international level. The athletes were in the top 6% of the athletes listed in the world rankings (DancesportInfo Rating System, 2011). The couples had been dancing together for the last 3.9±2.8 years. DanceSport participants reported practicing mainly DanceSport specific training but have also used physical preparation for the season (jogging, stretching, etc).

4.1.2. Ballet and contemporary dance participants

Eighty nine ballet dancers (33 males and 56 females) and 137 contemporary dancers (28 males, 109 females) volunteered to participate in the study. Ballet and contemporary dancers were professionals.

4.2. Experimental design

Anthropometric measurements (height and body mass) were measured and BMI was calculated on all the participants. Body fat percentage and somatotype characteristics were determined in 60 DanceSport dancers (30 males, 30 females), 49 ballet dancers (16 males, 33 females), 118 contemporary dancers (21 males, 97 females). Aerobic capacity (VO_{2max}) was measured in 60 DanceSport dancers (30 males, 30 females), 40 ballet dancers (17 males, 23 females) and 19 contemporary dancers (7 males, 12 females) (Table 3).

Table 3. The number of participants participating in different measurements

	DanceSport (n = 60)		**Ballet** (n = 89)		**Contemporary dance** (n = 137)	
	Male (Total n = 30)	**Female (Total n = 30)**	**Male (Total n = 33)**	**Female (Total n = 56)**	**Male (Total n = 28)**	**Female (Total n = 109)**
Anthropometry	30	30	33	56	28	109
Somatotype	30	30	16	33	21	97
Body composition	30	30	16	33	21	97
VO_{2max}	30	30	17	23	7	12
DanceSport competition simulation	30	30	0	0	0	0

DanceSport athletes also participated in competition simulation (Figures 1 and 2). Three separate testing sessions were carried out. During the first visit, the main anthropometric parameters and VO_{2max} on a treadmill were measured. The second measurement session was designed to establish physiological responses during simulation of dancing competition. The first and second measurement sessions were separated by approximately one week depending on the schedule of participants. Another measurement session consisted of body composition assessment by dual-energy X-ray absorptiometry (DXA), which was done within 48 h after the first measurement session depending on the schedule of participants and DXA availability.

4.3. Anthropometry, somatotypes and body composition

The height (Martin metal anthropometer) and body mass (A&D Instruments, UK) of the participants were measured to the nearest 0.1 cm and 0.05 kg, respectively, and body mass index (BMI) was calculated.

All anthropometric variables were measured according to the protocol recommended by International Society for the Advancement of Kinanthropometry (ISAK) (Norton & Olds, 1996). Nine skinfolds (*triceps, subscapular, biceps, iliac chest, supraspinale, abdominal, front thigh, medial calf, mid-axilla*), 13 girths (*head, neck, arm relaxed, arm flexed and tensed, forearm, wrist, chest, waist, gluteal, thigh, thigh mid trochanter-tibiale, calf, ankle*), 8 lengths (*acromiale-radiale, radialestylion, midstylion-dactylion, iliospinale-box height, trochanterion-box height, trochanterion-tibiale laterale, tibiale-laterale to floor, tibiale medial-sphyrion tibiale*) and 11 breadths/lengths (*biacromial, biiliocristal, foot length, transverse chest, antero-posterior chest depth, sitting height, humerus, femur, arm span, bideltoid breadth, bitrochanteric breadth*) were measured on the right side of the body. Three series of anthropometric measurements were taken from each site and the mean was recorded. Skinfold thickness were measured using a Holtain (Crymmych, UK) skinfold caliper, other anthropometric variables were measured using the Centurion Kit instrumentation (Rosscraft, Surrey, BC, Canada). Calibration of all equipment was conducted prior to and at regular intervals during the data collection period. The tester had the Level 1 ISAK competency.

The three somatotype components – endomorphy, mesomorphy and ectomorphy – were calculated according to the Heath-Carter (Carter & Heath, 1990) anthropometric somatotyping method.

Body composition was measured using DXA. Scans of the whole body were performed using a Lunar DPX-IQ densitometer (Lunar Corporation, Madison, WI, USA).

4.4. Incremental treadmill test

Maximal oxygen consumption was measured during an incremental treadmill test until voluntary exhaustion. The standardized 5 min warm up at 7 km·h^{-1} for males and at 5 km·h^{-1} for females was used. The incremental test started at 8 km·h^{-1} for males and 6 km·h^{-1} for females and speed was increased by 1 km·h^{-1} after every 2 min until voluntary exhaustion. Treadmill incline remained at 0% throughout the incremental test. Respiratory gas exchange variables were measured throughout the test in a breath-by-breath mode using a portable open circuit spirometry system (MetaMax 3B, Cortex Biophysic GmbH, Germany) and data were saved in 10 s intervals. Oxygen consumption (VO_2), carbon dioxide production (VCO_2) and minute ventilation (VE) were continuously measured, and the mean respiratory exchange ratio (RER) and ventilatory equivalents of O_2 ($VE \cdot VO_2^{-1}$) and CO_2 ($VE \cdot VCO_2^{-1}$) were calculated from the recorded measurements. The analyzer was calibrated before the test with gases of known concentration according to the manufacturer's instructions. All data were processed by means of computer analysis using standard software (MetaSoft, Cortex Biophysic GmbH, Germany) and the system for heart rate (HR) analysis. Anaerobic threshold (AT) determination was performed using linear regression turn point analysis (Hofmann et al., 2007). Turn points in HR, VE, $VE \cdot VO_2^{-1}$ and $VE \cdot VCO_2^{-1}$were calculated as described previously (Hofmann et al., 2007). Two regression lines were calculated and the inter-section point between both optimized regression lines was taken as the HR turn point and was used in the AT (HR/AT) analysis (Hofmann et al., 2007).

Capillary blood samples for enzymatic determination of lactate (LA) concentration in the capillary blood were collected from the finger-tip and analyzed using enzymatic photometric method (Dr Lange GmbH, Berlin, Germany) before warm-up (LA_0) and after 3 min (LA_{post}) of the treadmill test.

4.5. Competition simulation in DanceSport athletes

Competing is inherent only to DanceSport, therefore only DanceSport dancers participated in competition simulation. The competitive dance couples, after dressing in the appropriate costume and wearing competition shoes, danced Standard, Latin American or Ten Dance dances to simulate the competitive situation. Participants were instructed to force themselves as at the competition and to do regular warm-up. Standard and Latin American disciplines (Figure 1) consisted of three rounds, each round consisted of 5 dances (in total 15 dances). Ten Dance discipline (Figure 2) consisted of two rounds, each round consisted of 10 dances – 5 Standard and 5 Latin American Dances (all together 20 dances). The Standard Dance discipline consisted of Slow Waltz, Tango, Viennese Waltz, Foxtrot and Quickstep. The order of the Latin American sequence was Samba, Cha-Cha-Cha, Rumba, Paso Double and Jive. Each dance lasted for 2 min except Jive and Viennese Waltz which lasted for 90 s.

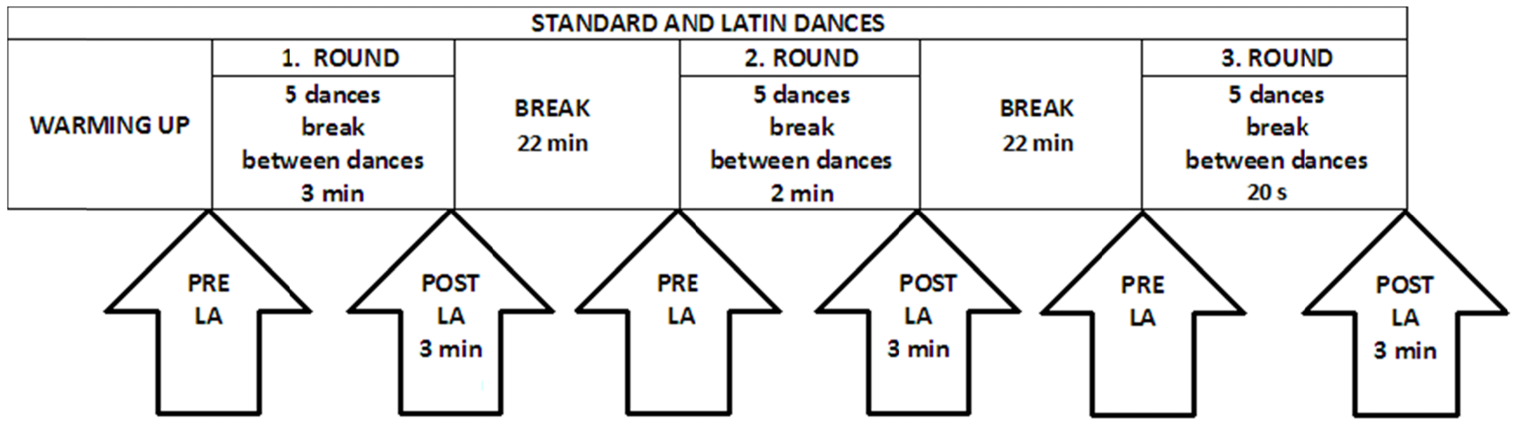


Figure 1. Standard and Latin American Dance competition simulation design. PRE LA – blood lactate concentration before dancing; POST LA – blood lactate concentration after dancing

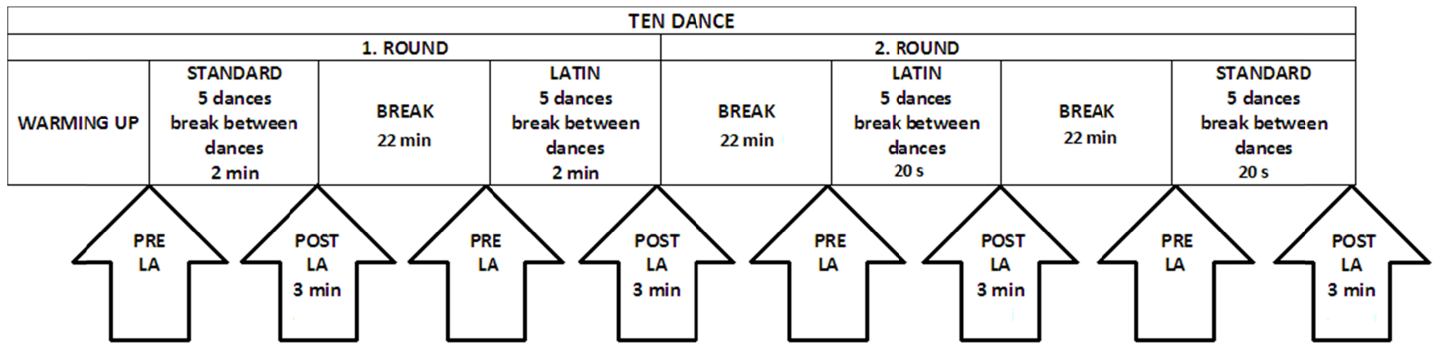


Figure 2. Ten Dance competition simulation design. PRE LA – blood lactate concentration before dancing; POST LA – blood lactate concentration after dancing

Rest period between rounds was 22 min. Rest periods between dances in Standard and Latin American disciplines first, second and third round were 3 min, 2 min and 20 s, respectively. Rest interval between the first round of Ten Dance competition was 2 min and between the second round dances 20 s. Competition simulation was completed in accordance with the WDSF Regulations for championship and competitive performances (WDSF Competition Rules, 2011) and all couples danced with the same music. During DanceSport competition simulation, HR was measured continuously using Polar Team System belt (Polar Electro Oy, Kempele, Finland). In addition, blood lactate values were measured before the warm-up, before each round and after 3 min at the end of each round using enzymatic photometric method (Dr Lange GmbH, Berlin, Germany). HR was recorded during the whole competition simulation. Mean HR values of each dance were calculated using Polar ProTrainer system and were shown as percentage from AT.

4.6. Statistical analysis

Data analysis was performed using IBM SPSS statistics 20.0 for Windows (Chicago, IL, USA). Means and standard deviations (SD) were calculated. Data were assessed for normality and the paired t-test was used to test for the differences between the male and female dancers. Analysis of Variance (ANOVA) with Scheffe and Tukey post-hoc tests were used to investigate differences in height, body mass and aerobic capacity parameters between Standard, Latin American and Ten Dance participants. The same analyses were used to compare anthropometric and somatotype parameters between ballet, contemporary dance and DanceSport participants. Pearson Product correlations were used to ascertain relationships between specific variables. Partial correlation analysis controlled for age was used to investigate the relationship between international ranking and training experience. The level of significance was set at $p<0.05$.

5. RESULTS

5.1. Anthropometry and body composition characteristics in DanceSport athletes

Anthropometric and body composition characteristics of male and female dancers participating in different dance styles are presented in Table 4. ANOVA analyses showed significant difference between the dance styles ($F_{2,54} = 13.45$; $p<0.01$) for height with post hoc tests indicating there were significant differences ($p<0.05$) between all three groups with Standard dancers being the tallest and Latin American the shortest. Analysis of the somatotype data reported Standard dancers having significantly higher ectomorphy scores than their Latin American counterparts ($F_{2,54}=8.37$, $p<0.05$) (Table 5 and Figure 3).

No significant differences between dance styles ($p>0.05$) were observed for mesomorphy or endomorphy. Standard dancers sitting height and arm span were significantly greater than Latin American dancers ($F_{2,54}=8.09$; $p<0.05$ and $F_{2,54} = 4.00$; $p<0.05$, respectively).

Intra-style analysis revealed a moderate positive correlation between international ranking and mesomorphy ($r=0.434$, $p<0.05$) and a negative correlation with ectomorphy ($r=-0.546$, $p<0.001$) for Standard dancers. There were no relationships between international ranking and somatotype in the other two styles.

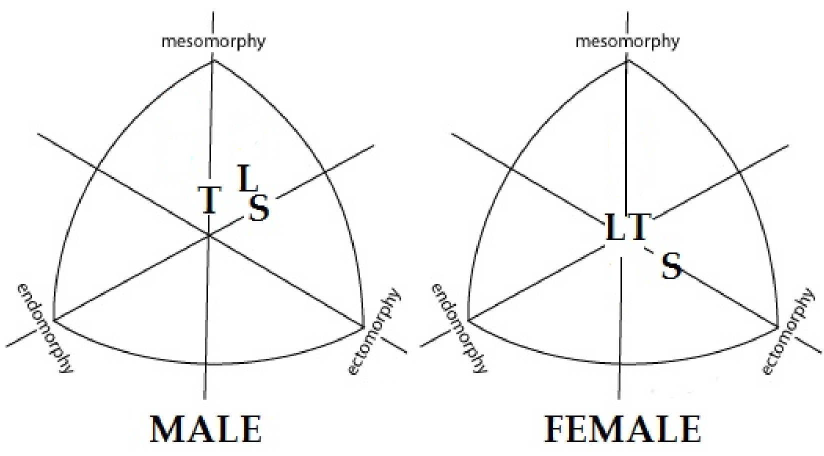


Figure 3. Male and female mean somatotypes for the DanceSport dancers. S – Standard Dance; L – Latin American Dance; T – Ten Dance.

Table 4. Mean (± SD) anthropometric, body composition characteristics and training experience of male and female dancers participating in different DanceSport styles

	Standard		**Latin**		**Ten Dance**	
	Male (*n* = 12)	**Female (*n* = 12)**	**Male (*n* = 7)**	**Female (*n* = 7)**	**Male (*n* = 11)**	**Female (*n* = 11)**
Age (yrs)	26.7±8.3	25.3±8.4	21.5±2.3	21.1±3.1	19.4±2.7	19.0±3.3
Height (m)	183.4±3.6	170.9±4.3*	175.4±3.7#	162.7±4.6*#	180.4±6.6	166.6±4.5*
Body mass (kg)	72.5±4.6	57.3±5.0*	70.0±5.1	53.4±4.4*	72.3±8.2	55.5±4.0*
BMI ($kg \cdot m^{-2}$)	21.6±1.4	19.6±1.3*	22.7±1.3	20.2±1.0*	20.1±1.1	20.1±1.4*
Body fat (%)	11.2±3.3	20.9±3.0*	13.4±3.3	22.6±5.6*	14.9±5.3	22.6±3.1*
Fat mass (kg)	7.9±2.6	11.4±2.3	9.0±2.5	12.2±3.5	10.4±4.2	11.9±1.8
Fat free mass (kg)	61.8±3.5	43.2±5.0*	57.9±4.3	38.5±3.2*	59.0±7.2	42.3±5.0*
Years of training	16.8±7.9	15.8±5.5	13.5±8.5	15.5±8.1	12.8±3.9	13.2±3.5
Training volume ($h \cdot w^{-1}$)	11.7±4.7	12.1±5.7	13.4±10.1	16.2±9.4	10.3±5.8	10.7±5.7

* indicates significant difference $p<0.05$ between males and females in the same dance style; # indicates significant difference $p<0.05$ between Standard and Latin dancers of the same gender. $h \cdot w^{-1}$ – hours per week. BMI – body mass index.

Table 5. Mean (± SD) somatotype and anthropometric characteristics of male and female dancers in different DanceSport styles

	Standard			**Latin**			**Ten Dance**		
	Male (*n* = 12)	**Female (*n* = 12)**	**Group (*n* = 24)**	**Male (*n* = 7)**	**Female (*n* = 7)**	**Group (*n* = 14)**	**Male (*n* = 11)**	**Female (*n* = 11)**	**Group (*n* = 22)**
Endomorphy	2.2±0.6	2.5±0.5	2.3±0.6	2.4±0.4	3.1±1.0	2.8±0.8	2.6±0.8	3.1±1.0	2.7±0.7
Mesomorphy	3.7±0.8	2.5±0.8	3.1±1.0	4.3±0.4	3.0±0.6	3.6±0.8	3.9±0.8	3.0±0.6	3.3±1.0
Ectomorphy	3.6±0.7	3.9±0.7	3.8±0.7	2.6±0.6	3.1±0.5	2.8±0.6$^{¤}$	3.2±0.6	3.4±0.9	3.4±0.8
Sitting height (cm)	94.6±1.7	89.1±2.8	92.0±3.7	91.2±2.5	85.9±2.9	88.5±3.8$^{¤}$	92.6±3.3	87.3±2.7	90.0±4.1
Arm span (cm)	187.0±4.8	172.8±4.3	179.9±8.5	180.4±3.0	163.7±6.7	172.0±10.0$^{¤}$	182.7±8.8	169.3±6.3	176.0±10.0
Trochanterion (cm)	0.94±0.0	0.84±0.2*	0.89±0.1	0.89±0.0$^{\#}$	0.82±0.0*	0.86±0.0	0.92±0.1	0.85±0.0*	0.89±0.1

* – significant difference p<0.05 between males and females of the same dance style; # – significant difference p<0.05 between Standard and Latin Dance participants of the same gender; ¤ – significant difference p<0.05 between Standard and Latin Dance groups

5.2. Aerobic capacity and competition simulation in DanceSport athletes

Physiological characteristics of male and female dancers participating in different dance styles are shown in Table 6. Anaerobic threshold is abbreviated as AT. Male athletes had significantly higher VO_2 and maximum treadmill speed at the end of the test ($p<0.05$) for all dance styles compared to the female athletes. However, VO_{2max} ($ml \cdot min^{-1} \cdot kg^{-1}$) values were higher only in Standard and Ten Dance group. In addition, LA_{post} values after treadmill test where significantly higher in males in Standard and Latin American group compared to females. No differences ($p>0.05$) in anaerobic threshold ($beats \cdot min^{-1}$), anaerobic threshold (% HR max) and LA_0 between genders and different dance styles were seen (Table 6).

Mean heart rate percentages from anaerobic threshold during competition simulation in different DanceSport styles are shown in Figure 4. Male and female Latin dancers had significantly higher average HR values compared to HR/AT values during the first (male 100.9±2.4% female 104.5±6.9%), second (male 100.9±4.2 female 105.8±5.8) and third (male 104.1±4.1% female 107.7±5.8%) round compared to the same gender Standard dancers first (male 96.5±2.7% female 95.7±3.3%), second (male 96.5±2.7% female 96.7±3.9%) and third (male 99.2±4.1% female 101.2±4.2%) rounds (Figure 4). In addition, female Latin dancers had significantly higher HR values in first (104.5±6.9%) and second (105.8±5.9%) round compared to Ten Dance females first round Standard (98.2±5.8%) and Latin American dances (98.4±5.3%) and in the third (107.7±5.8%) round compared to Ten Dance female second round in Standard (99.4±6.5%) and Latin American Dances (100.9±5.6) (Figure 4).

The mean HR values compared to HR/AT observed in male and female dancers during the whole competition simulation for each dance style are given in Table 6. It appeared that male and female Standard dancers tended to perform lower than AT intensity, while Latin and Ten Dance competition intensity was higher compared to individual AT. In addition, HR values compared to HR/AT in female Standard and Ten Dance dancers during competition were significantly lower (Standard 97.9±3.6%; Ten Dance 99.2±5.6%) compared with Latin American dancers (106.7±5.9%) of the same gender (Table 6).

Table 6. Mean (± SD) physiological characteristics during the incremental treadmill test and competition simulation of male and female dancers participating in different DanceSport styles

	Standard		Latin		Ten Dance	
	Male (n = 12)	**Female (n = 12)**	**Male (n = 7)**	**Female (n = 7)**	**Male (n = 11)**	**Female (n = 11)**
VO_2 ($l \cdot min^{-1}$)	4.4±0.5	3.0±0.4*	4.3±0.2	2.2±0.3*	4.2±0.7	2.80.4*
VO_{2max} ($ml \cdot min^{-1} \cdot kg^{-1}$)	59.6±4.8	51.8±4.6*	61.3±5.3	53.6±5.4	59.4±5.9	50.0±7.6*
HR max ($beats \cdot min^{-1}$)	191.8±6.1	193.3±5.3	195.9±4.8	191.6±10.7	196.6±10.0	195.6±6.9
Maximum Speed ($km \cdot h^{-1}$)	17.3±1.9	13.8±1.1*	16.1±1.6	13.6±1.1*	15.8±1.5	13.0±1.2*
AT ($beats \cdot min^{-1}$)	175.3±5.4	177.5±7.7	179.3±8.5	179.1±12.6	177.7±10.0	179.5±8.2
AT (% HR max)	91.4±3.5	92.2±2.7	91.5±3.4	93.6±5.3	90.6±5.6	91.8±3.6
LA_0 ($mmol \cdot l^{-1}$) treadmill	1.6±0.7	1.8±0.6	1.8±0.4	2.1±1.1	2.1±0.7	1.8±0.6
LA_{post} treadmill ($mmol \cdot l^{-1}$)	11.6±2.3	8.4±2.2*	11.7±3.1	7.5±2.2*	9.6±2.2	7.8±2.0
HR/AT dance (%)	97.3±2.9	97.9±3.6	101.4±2.9	106.7±5.9#	100.7±6.4	99.2±5.6¤
LA_{post} 1 ($mmol \cdot l^{-1}$)	8.7±3.6	8.6±3.3	12.4±3.7	8.3±3.5	10.2±2.3	7.5±2.2
LA_{post} 2 ($mmol \cdot l^{-1}$)	8.6±3.2	8.2±3.5	12.4±3.7	7.2±3.1	7.3±2.4	6.1±3.1
LA_{post} 3 ($mmol \cdot l^{-1}$)	8.4±2.9	7.8±2.7	12.2±2.8	7.0±3.2	6.1±2.4	5.3±3.2
LA_{post} 4 ($mmol \cdot l^{-1}$)					6.0±1.5	4.7±1.9

* – significant difference $p<0.05$ between males and females in the same dance style; # – significant difference $p<0.05$ between Standard and Latin American dancers of the same gender; ¤ – significant difference $p<0.05$ between Latin and Ten Dance dancers of the same gender. HR – heart rate; LA – blood lactate concentration; VO_2 – oxygen uptake. AT – anaerobic threshold; LA_0 ($mmol \cdot l^{-1}$) treadmill – blood lactate concentration before treadmill test; LA_{post} 1, 2 ,3 ,4 – lactate after each round of five dances; HR/AT dance – competition simulation mean HR values' from anaerobic threshold.

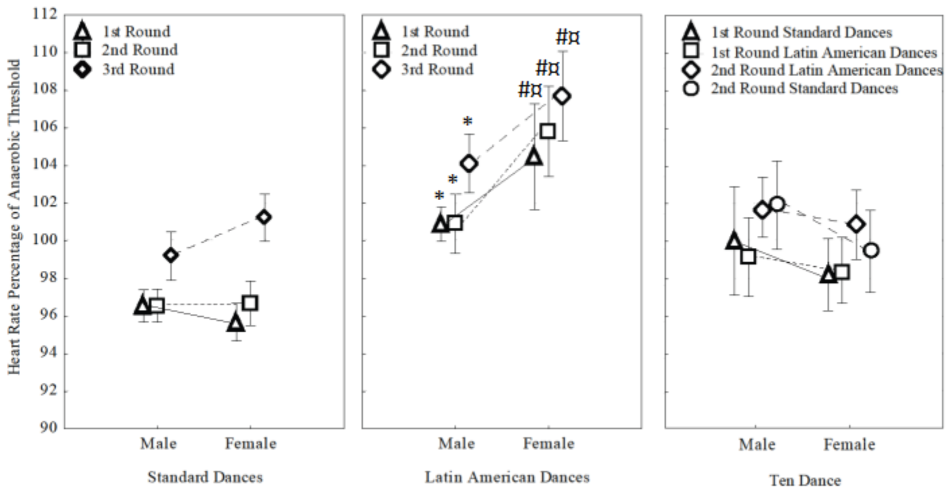


Figure 4. Mean (± SE) heart rate percentages from anaerobic threshold during competition simulation in different DanceSport styles. * – significant difference (p<0.05) between male Standard and Latin American dances groups. # – significant difference (p<0.05) between female Standard and Latin American dances groups. ¤ – significant difference (p<0.05) between female Latin American and Ten Dance groups.

The mean HR values compared to HR/AT recorded in male and female dancers for each individual dance are presented in Figure 5. In general, male and female Standard dancers had significantly higher relative HR values in Viennese Waltz, Slow Foxtrot and Quickstep compared with Slow Waltz and Tango. In addition Standard male dancers had significantly higher mean HR values in Viennese Waltz, Slow Foxtrot and Quickstep during third round compared to the first and second round (p<0.05) (Figure 5A). Female Standard dancers had significantly higher mean HR values in Tango, Viennese Waltz, Slow Foxtrot and Quickstep compared with Slow Waltz. In Tango and Quickstep mean HR values where significantly higher during third round compared to the first and second round and in Viennese Waltz and Slow Foxtrot mean HR values where significantly higher during third round compared to the first round (p<0.05) (Figure 5B). Male Latin American dancers had significantly higher mean HR compared to HR/AT values in Paso Doble and Jive during third round compared to the first and second round (Figure 5C) and Female Latin American dancers had significantly higher mean HR values in third round Jive compared to the first round (Figure 5D). Male Ten Dance athletes had higher mean HR values in Rumba, Paso Doble and Jive during the second round compared to the first round (Figure 5E). Female Ten Dance dancers had higher values in Jive during second round compared to the first round (Figure 5F). During the whole dance competition simulation mean HR compared to HR/AT were significantly higher (p<0.05) in female Latin dancers (106.7±5.9%) compared with female Standard dancers (97.9±3.6%) and female Ten Dance dancers (99.2±5.6%) corresponding values (Table 6). In addition, there were no significant difference between male and female HR in all ten dances, all rounds and dance disciplines compared in to the same dance and round.

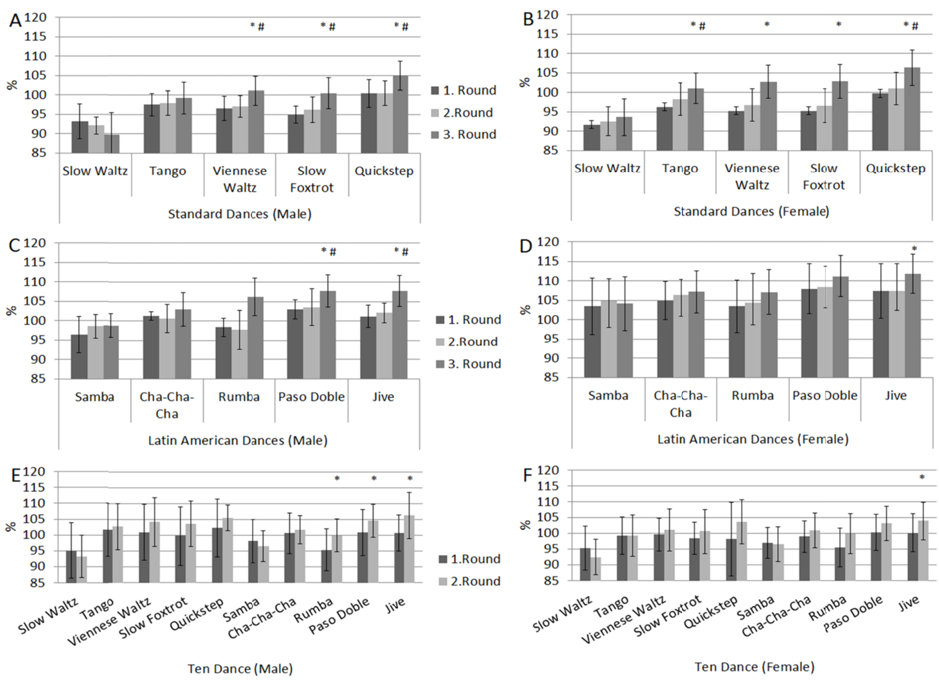


Figure 5. Mean (± SD) heart rate percentages of anaerobic threshold during competition simulation in different dances by DanceSport style.

* – significant difference p<0.05 between the first and last round. # – significant difference p<0.05 between second and third round

There were no significant differences in LA_{post} values during competition simulation between three dance styles and both genders (Table 6). There was no significant relationship between VO_{2max} values and international rating. However, partial correlation analysis between international ranking and training experience controlling for age revealed the significant positive relationship ($r = 0.56$, $p<0.001$) which means that irrespective of the age, dancers with higher places on the international ranking have also longer training experience.

5.3. Comparison of anthropometry, body composition and aerobic capacity between DanceSport, contemporary dance and ballet dancers

Anthropometrical characteristics of the subjects of different dance genres are presented in Table 7. There were significant differences in height ($F_{2, 280} = 9.677$, $p<0.001$), body mass ($F_{2, 280} = 11.912$, $p<0.001$), and BMI ($F_{2, 280} = 18.822$, $p<0.001$) values between different dance genres. Post hoc tests indicated that male and female DanceSport dancers were taller compared to same gender contemporary dance participants ($p<0.05$). Female contemporary dance and DanceSport dancers had higher body mass and BMI values compared with female ballet dancers ($p<0.001$). Female contemporary dancers had higher BMI values compared with female DanceSport dancers ($p<0.05$). There was a significant difference in age ($p<0.05$), height, body mass and BMI ($p<0.001$) between genders.

There was a significant difference in VO_{2max} values between three dance genres ($F_{2,112} = 33.724$, $p<0.001$) and post hoc tests indicated DanceSport dancers having significantly higher ($p<0.01$) VO_{2max} values compared to ballet and contemporary dancers (Table 8).

There were significant differences in body fat percentage ($F_{2,112} = 5.524$, $p<0.05$) values between dance genres. Female contemporary and female DanceSport athletes had higher body fat percentage compared with female ballet dancers ($p<0.01$).

Somatochart of different dance genres is shown in Figure 6 and somatotype characteristics of male and female dancers in different dance genres is shown in Table 8. There were significant differences between endomorphy ($F_{2,221} = 8.773$, $p<0.01$) and mesomorphy ($F_{2, 221} = 21.458$, $p<0.001$) characteristics between dance genres. Female DanceSport dancers had lower endomorphy values compared to female ballet and contemporary dancers ($p<0.01$). Female ballet dancers had lower mesomorphy values compared to female contemporary ($p<0.05$) dancers. In contrast, female ballet dancers had higher mesomorphy score compared to female DanceSport participants. Male ($p<0.05$) and female ($p<0.01$) contemporary dancers had higher mesomorphy values compared to same gender DanceSport dancers. There was a significant difference between genders in body fat percentage, endomorphy and mesomorphy values ($p<0.01$). There were no significant differences in ectomorphy scores.

Table 7. Mean (± SD) anthropometrical characteristics and body mass index of male and female dancers in different dance genres

	Ballet		**Contemporary**		**DanceSport**	
	Male (*n* = 33)	**Female (*n* = 56)**	**Male (*n* = 28)**	**Female (*n* = 109)**	**Male (*n* = 30)**	**Female (*n* = 30)**
Age (yrs)	22.4±4.6	21.1±4.5	24.7±4.8	22.0±3.2	22.8±6.6	22.0±6.4
Height (m)	1.78±0.07	1.64±0.04	1.76±0.06	1.64±0.1	1.80±0.06$^{¤}$	1.67±0.05$^{¤}$
Body mass (kg)	67.5±7.4	50.4±4.9	68.1±7.4	55.7±6.3$^{\#\#}$	71.9±6.1	55.7±4.6§§
BMI ($kg{\cdot}m^{-2}$)	21.3±1.6	18.7±1.3	22.0±1.8	20.8±1.8$^{\#\#}$	22.0±1.3	19.9±1.2$^{\S\S¤}$

BMI – body mass index. ## – significant difference $p<0.01$ between ballet and contemporary dancers group of the same gender; §§ – significant difference $p<0.01$ between ballet and DanceSport group of the same gender; ¤ – significant difference $p<0.05$ between contemporary and DanceSport dancers group of the same gender.

Table 8. Mean (± SD) body fat percentage, maximal oxygen uptake and somatotype characteristics of male and female dancers in different dance genres

	Ballet		Contemporary		DanceSport	
Anthropometry	**Male (n = 16)**	**Female (n = 33)**	**Male (n = 21)**	**Female (n = 97)**	**Male (n = 30)**	**Female (n = 30)**
Body fat (%)	12.7±2.9	17.5±2.5	13.0±1.0	21.2±3.8$^{\#\#}$	13.1±4.3	21.9±3.8§§
Endomorphy	2.3±0.9	3.6±0.8	2.6±0.7	3.8±1.1	2.4±0.6	2.7±0.7$^{§§¤¤}$
Mesomorphy	4.6±1.6	3.4±1.1	4.9±1.2	4.1±1.0$^{\#}$	3.9±0.7$^{¤}$	2.7±0.8$^{§¤¤}$
Ectomorphy	2.6±1.0	3.7±1.0	3.0±1.0	3.3±5.2	3.2±0.8	3.5±0.8
Incremental exercise test	**(n = 17)**	**(n = 23)**	**(n = 7)**	**(n = 12)**	**(n = 30)**	**(n = 30)**
VO_{2max} (ml·min^{-1}·kg^{-1})	49.6±3.9	43.7±5.1	56.9±4.9$^{\#}$	47.5±6.4	60.0±5.2§§	51.5±6.0§

– significant difference p<0.05 between ballet and contemporary dancers group of the same gender; ## – significant difference p<0.01 between ballet and contemporary dancers group of the same gender; § – significant difference p<0.05 between ballet and DanceSport dancers group of the same gender; §§ – significant difference p<0.01 between ballet and DanceSport group of the same gender; ¤ – significant difference p<0.05 between contemporary and DanceSport dancers group of the same gender; ¤¤ – significant difference p<0.01 between contemporary and DanceSport dancers group of the same gender.

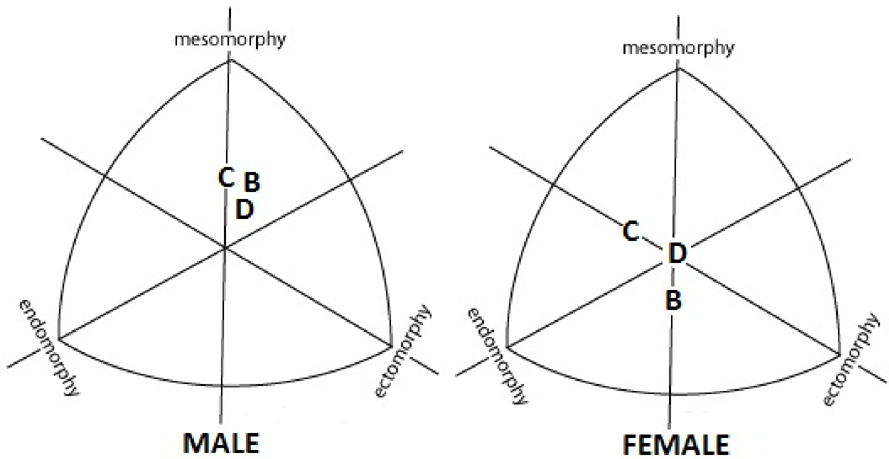


Figure 6. Mean somatotypes for male and female B – ballet, C – contemporary dance and D – DanceSport dancers.

6. DISCUSSION

6.1. Anthropometry and body composition characteristics in DanceSport athletes

The importance of the morphological characteristics for optimal performance in aesthetic sports is noted in most systems models for analyzing sport (Bloom, 1985; Bompa, 1985; Franks & Goodman, 1986; Malina, 1994, Monsma & Malina, 2005). The present study, to the authors' knowledge, is the first study that has examined differences of the anthropometric profiles of elite dancers in the different DanceSport styles.

The results of present study demonstrate that Standard Dance dancers with higher muscularity are more successful and that Standard dancers tend to have greater arm span and sitting height compared to Latin American dancers. Latin American dancers tend to be shorter compared to Standard dancers. As Ten Dance dancers perform both dance styles their body proportions do not different significantly from Standard and Latin American dancers.

The required graceful, flowing movements of Standard Dance are in contrast to high energy, dynamic choreography seen in Latin American Dance. The observed variances in anthropometric measures could be a reflection of the different choreographic demands of the different styles; with Standard Dance being more expansive than Latin American. The greater ectomorphy, limb length and sitting height lends itself to the portrayal of effortless grace whilst the more mesomorphic and less ectomorphic somatotype of Latin American Dance would benefit the fast leg movement, and turn seen in its choreography (see Table 5).

Although Standard Dance dancers had significantly higher ectomorphic rating compared with Latin American dancers the results surprisingly revealed that Standard dancers who had higher mesomorphic scores had also higher international ranking score. This suggests that although long bodylines are important in Standard Dances, a level of muscularity is also required. The level of mesomorphy for all the DanceSport styles is still comparatively low in comparison with the other aesthetic sports, especially in male competitors (Carter, 1970; Faulkner, 1976; Twitchett et al., 2008). This highlights the reduced requirement of strength and power within DanceSport due to the choreographic limitations of the styles.

Standard Dance dancers were significantly taller compared with Latin American dancers. Surprisingly the significant difference came from the back area (sitting height) not from the length of the legs (*trochanterion*). This can be explained by the nature of Standard Dances that requires graceful back arches as part of its artistic elements, especially for the female competitors. Moreover, Standard Dancers had also significantly longer arm span and *trochanterion*. Therefore, the results of the current study suggest that dancers with relative longer limbs should be favored in Standard Dances compared to Latin ones.

There were no significant difference in somatotypes, sitting height and arm span between Ten Dance group compared with both Standard and Latin American Dance groups. This could be because Ten Dance dancers have to be able to compete in both styles and therefore a somatotype in between of the other two styles is ideal to cope with the diverse choreography and aesthetic lines.

In summary, the findings of this study show that somatotypes also differ among DanceSport dancers by dance style. Standard dancers tend to be more ectomorphic with greater height, arm span and sitting height compared with Latin American dancers. Although Standard dancers were ectomorphic, those dancers who had higher mesomorphic scores had higher international ranking.

6.2. Aerobic capacity and competition simulation in DanceSport athletes

One of the aims was to study aerobic capacity of international level DanceSport dancer's during incremental test and competition simulation in relation to the gender, dance style and international ranking. The novelty of the present research lies in competition simulation which was more similar to the real competition compared to previous researches have done in the field. Competition simulation in the present research consisted of more than one dance round and 15–20 dances. This simulation gives better understanding of the effort of DanceSport dancers during the competition. In addition, for the first time we added Ten Dance discipline in to the study and compared three DanceSport styles (Standard, Latin and Ten Dance). The results of our study indicated that the dancers of three disciplines had similar aerobic capacity, however those values were lower compared to other athletes (Koutedakis & Jamurtas, 2004).

In this study we hypothesized that the intensity of rounds is increasing from the first round up to third and that Ten Dance discipline demands higher aerobic and anaerobic capacity values compared to other dance styles. Surprisingly, the results showed that Latin American dance discipline was found physiologically more intensive compared to Standard and Ten Dance characterized by significantly higher HR values during the first, second and third round compared to the same gender Standard and Ten Dance dancers (see Figure 4). Moreover, female Latin dancers had significantly higher HR values during first and second round compared to Ten Dance female first round Standard and Latin American Dances and in the third round compared to Ten Dance female second round in Standard and Latin American Dances (see Figure 4). Based on these results we can conclude that performance intensity is the highest in the Latin American discipline compared to Standard and Ten Dance, especially for the female Latin American dancers. This was also confirmed by significantly higher relative HR (106.7±5.9%) in female Latin dancers compared female Standard dancers (97.9±3.6%) and female Ten Dance dancers (99.2±5.6%) corresponding values (see Table 6).

Male and female dancers' VO_{2max} values (see Table 6) were similar compared to the latest research in this field (Bria et al., 2011; Jensen et al., 2002; Klonova et al., 2011) but higher compared to earlier research (Blanksby & Reidy, 1988). However, it was interesting to note that despite significantly higher competitive intensity, Latin American dancers did not have higher VO_{2max} values compared to other DanceSport styles. This was even more relevant for Latin American female dancers, whose competitive intensity was relatively highest compared to other dancers. It seems that unlike most athletes where aerobic fitness and performance levels increase in parallel during their careers, dancers develop these two parameters independently. The selection and dance-only training system currently in use may account for this (Koutedakis & Jamurtas, 2004). We also did not find any significant differences between body fat mass or fat free mass when comparing subjects of different DanceSport disciplines. Therefore, it could be suggested that Latin American dancers could benefit from better training of aerobic capacity in order to accommodate better with the higher intensities used in Latin dances. Despite the fact that a typical DanceSport competition requires the athletes to dance throughout the day for approximately 10 h, and to be recalled through a number of rounds (approximately 3–6 rounds), before reaching the final dance round, we found no significant relationship between VO_{2max} values and dance couples international ranking. The same result was also confirmed by Klonova et al. (2011). However, irrespective of the age, dancers who had higher international ranking had also longer training experience. This indicates that good aerobic capacity is important in order to reach and compete on the high level in DanceSport and compete on that level but competition results are also determined by other characteristics like training experience.

The results of competition simulation test also indicated that the intensity of performance increased during each round in all dances and dance styles (except for Standard Dance sequence first dance – Slow Waltz were it was decreased) (see Figure 5). It indicates that the multiple round competition simulation yields to different results in regard of physical performance compared to single round competition analysis. In addition, the highest HR during competition simulation was always found during the last dances (Paso Double, Jive or Quickstep) and in the last round in all dance styles. This demonstrates that dancers are distributing energy resources during effort and putting out their maximum at the end of the round and competition similar to other sport disciplines. Similarly to our results, Bria et al. (2011) measured the highest intensity in female Standard dancers in Quickstep (VO_2 43.0±8.0 $ml \cdot min^{-1} \cdot kg^{-1}$) and in female Latin American dancers in Paso Double (VO_2 43.4±7.1 $ml \cdot min^{-1} \cdot kg^{-1}$). In male dancers, Bria et al. (2011) found different results from our results. They reported highest intensity for Standard male dancers in Viennese Waltz (VO_2 49.3±5.2 $ml \cdot min^{-1} \cdot kg^{-1}$) and for male Latin dancers in Cha-Cha-Cha (VO_2

50.7±6.6 $ml \cdot min^{-1} \cdot kg^{-1}$). We found no significant difference in mean HR in any dance between males and females indicating how similarly dancing partners work during the competition.

We also compared Ten Dance discipline to Standard and Latin American dances. The results showed that the dancers of three disciplines had similar aerobic capacity values. Ten Dance discipline consists five Standard and five Latin American dances this may be the main reason why Ten Dance dancers did not have significant differences in any physical characteristics compared to other dance style same gender participants (see Table 6) and the only significant difference in physiological characteristics (see Table 6 and Figure 4) was found in HR during the dance between female Ten Dance and Latin dancers.

In DanceSport competition simulation, there were no significant differences in LA_{post} values between different dance styles. However, it can be seen that although dancers in general, danced in the range of their anaerobic threshold (except for female Latin dancers whose intensity was approximately 6% higher than anaerobic threshold) their post dance lactate values were relatively high, being in the range of 8–12 $mmol.l^{-1}$. This finding is difficult to explain, however as the dancing recruits higher proportion of the muscles in combination of the static holds compared to running, might reflect also in higher lactate production and higher post dance lactate concentration. Therefore, the estimation of anaerobic threshold intensity for dancers on treadmill probably overestimates the lactate accumulation intensity during competitive dancing. The second explanation for high lactate values after dancing competition simulation may be related to the fact that dancing performance intensity is changing during performance so that in some point heart rate may be strongly over the anaerobic threshold this, in turn may rise blood lactate concentration. An essential point in this situation may also be the fact that blood lactate value where measured after most intensive dance (Jive or Quickstep).

One of the limitations of this study was the absence of judges measuring the dance quality during competition simulation that could alter the effort of dancing. However, during the completion simulation the coaches were always present encouraging the subjects for both, intensive dancing and artistry.

In summary, the results of present investigation demonstrated that international level DanceSport dancers of different styles have relatively high aerobic capacity values and the aerobic capacity values of the three dance styles are rather similar. However, Latin American competitive intensity was higher than Standard Dances, especially for female Latin American dancers. No significant relationship was found in the current study between the international ranking and aerobic capacity values.

6.3. Comparison of anthropometry, body composition and aerobic capacity between DanceSport, contemporary dance and ballet dancers

One of the aims of the present study was to assess the homogenity of professional dancers for anthropometric variables and aerobic capacity. Within the literature of exercise science there have been very few studies that have compared different dance genres to ascertain whether there are uniform characteristics such as body shape and aeriobic fitness between three different dance genres: classical ballet, contemporary dance and DanceSport. Within sport it is well established that different sports require participants to have specific anthropometric and physical characteristics to compete at an elite level (Bandyopadhyay, 2007; Duncan et al., 2006). It has also been suggested that functional adaptation due to different training regimens may be responsible for the determination of some anthropometric changes (Del Balso & Cafarelli, 2007).

Height, body mass, body fat percentage and VO_{2max} values of classical ballet, contemporary dance and DanceSport dancers in the current study were similar to those reported in previous studies (Berlet et al., 2002; Bria et al., 2011; Chmelar et al., 1988; Harley et al., 2002). Female ballet dancers had the lowest body fat percentage, body mass and BMI compared with female contemporary dance and DanceSport dancers (see Tables 7 and 8), confirming the genre's requirements for female dancers to be light, low body fat content and low body mass, in order to perform the tasks related to classical ballet (Tsunawake et al., 2003). The lowest body fat percentage, body mass and BMI of female ballet dancers compared with female contemporary dance and DanceSport dancers may refer to different aesthetical values of ballet, contemporary dance and DanceSport dancers. The observed higher height of DanceSport athletes compared to contemporary dancers may be related to the fact that DanceSport does not have lifts within its choreography that requires the female dancer to be lifted above the head where her body mass could become an issue. The choreography, especially with Standard dances, requires big movements and shapes, especially in the upper body, which is enhanced by having a taller frame and longer limbs. Standard Dance is one of three DancesSport disciplines where five Standard dances (Waltz, Tango, Viennese Waltz, Slow Foxtrot and Quickstep) are performed. All Standard dances demand wide movement and big shapes in dancehold bigger height and longer limbs probably help to achieve this.

There were significant differences in mesomorphic and endomorphy scores between three dance styles (see Table 8). Female DanceSport dancers are less mesomorphic and endomorphic then female of the other two dance styles and female contemporary dance dancers are more mesomorphic compared to the female ballet dancers. The reason for higher mesomorphy scores for contemporary dance dancers may be because unlike most ballet dancers, contemporary dance has less of a gender divide within the choreographed movements

(Wyon et al., 2011) and the dancers often come from a multidisciplinary background (e.g. gymnastics) (Koutedakis & Jamurtas, 2004).

It has been suggested that dancers would benefit from aerobic training (Allen & Wyon, 2008) and high anaerobic threshold limits the effects of fatigue such as a decrease in balance, poise, and coordination (Baldari & Guidetti, 2001; Bria et al., 2011; Wyon & Koutedakis, 2013). The DanceSport participants recorded the highest maximal oxygen consumption whilst classical ballet dancers demonstrated lower maximal oxygen consumption than contemporary dancers (see Table 8). These differences could be due to the variation in physical demands of dancing between different genres. Classical ballet and contemporary dance are noncompetitive and dancers do not need to strive against others during performance. DanceSport in contrast requires competing throughout the day and to be recalled through a number of rounds before reaching the final. This difference between the genres is especially highlighted in the aerobic capcity of female dancers where the DanceSport participants have significantly higher VO_{2max} than other two genres. This could be due to the training and competitive requirements of DanceSport, and especially Standard dances, that require the female dancers to match their male partners stride for stride.

In summary, classical ballet, contemporary dance and DanceSport dancers differ by somatotypes. Female contemporary dancers are generally more muscular than their ballet counterparts, whilst DanceSport dancers are taller and heavier and less muscular compared to the classical ballet and contemporary dancers. Ballet dancers had lowest body fat percentage, body mass and BMI values. DanceSport dancers had greater aerobic capacity compared to the ballet and contemporary dancers. Based on the results of this study we can conclude that classical ballet, contemporary dance and DanceSport professionals differ in some aspects of anthropometric variables, somatotypes and aerobic capacity.

7. CONCLUSIONS

1. Standard dancers with higher muscularity are more successful and they tend to be more ectomorphic with greater height, arm span and sitting height compared to Latin American dancers. Although Standard dancers were ectomorphic, those dancers who had higher mesomorphic scores had higher international ranking. The body proportions of Ten Dance dancers did not differ from Standard and Latin American dancers.
2. Aerobic capacity values in international level DanceSport dancers of different styles are relatively high and do not differ between three dance styles (Standard Dance, Latin American Dance and Ten Dance). However, the competitive intensity of Latin American dancers was higher than Standard Dances, especially for female Latin American dancers. No relationship was found between the international ranking and aerobic capacity values.
3. DanceSport dancers are taller, heavier and less muscular compared to the classical ballet dancers, whilst female contemporary dancers are generally more muscular than their ballet counterparts. Ballet dancers had lowest body fat percentage, body mass and BMI values. DanceSport dancers had greater aerobic capacity compared to the ballet and contemporary dancers. It appeared that classical ballet dancers, contemporary dance dancers and DanceSport professionals differ in some aspects of anthropometric variables, somatotypes and aerobic capacity.

8. REFERENCES

Allen N, Wyon M. Dance medicine: Artist or athlete? SportEX Med, 2008; 35: 6–9.

Angioi M, Metsios G, Koutedakis Y, Wyon MA. Fitness in Contemporary Dance: A Systematic Review. Int J Sports Med, 2009; 30: 475–484.

Baldari C, Guidetti L. VO2max, ventilatory and anaerobic thresholds in rhythmic gymnasts and young female dancers. J Sports Med Phys Fitness 2001; 41: 177–182.

Bandyopadhyay A. Anthropometry and body composition in soccer and volleyball players in West Bengal, India. J Physiol Anthropol, 2007; 24: 501–505.

Berlet GC, Kiebzak GM, Dandar A, Wooten C, Box JH, Anderson RB, Davis WH. Prospective analysis of body composition and SF-36 profiles in professional dancers over a 7-month season. Is there a correlation to injury? J Dance Med Sci 2002; 6: 54–61.

Blanksby BA, Reidy PW. Heart rate and estimated energy expenditure during ballroom dancing. Br J Sports Med, 1988; 22: 57–60.

Bloom BS. Generalizations about talent development. Developing talent in young people. Ballentine Books, New York, 1985; 507–549.

Bompa T. Talent identification. Science periodical on research and technology in sport. coaching association of Canada, Ottawa, 1985; 1–11.

Bria S, Bianco M, Galvani C, Palmieri V, Zeppilli P, Faina M. Physiological characteristics of elite sport-dancers. J Sports Med Phys Fitness, 2011; 51: 194–203.

Brown AC, Wells TJ, Shade ML, Smith DL, Fehling PC. Effects of plyometric training versus traditional weight training on strength, power, and aesthetic jumping ability in female collegiate dancers. J Dance Med Sci, 2007; 11: 38–44.

Carter JE, Ackland TR, Kerr DA, Stapff AB. Somatotype and size of elite female basketball players. J Sports Sci, 2005; 23: 1057–1063.

Carter JEL, Heath BH. Somatotyping: Development and applications. Cambridge University Press, Cambridge, 1990.

Carter, JE, The somatotypes of athletes – a review. Hum. Biol. 1970; 42: 535–569.

Chmelar RD, Schultz BB, Ruhling RO. A physiologic profile comparing levels and styles of female dancers. Phys Sportsmed, 1988; 16: 87–96.

Cohen JL, Segal KR, Witriol IRA, MacArdle WD. Cardiorespiratory responses to ballet exercise and the VO2max of elite ballet dancers. Med Sci Sports Exerc, 1982; 14: 212–217.

Coutts RA, Gilleard WL, Hennessy M, Silk A, Williams G, Weatherby RP. Development and assessment of an incremental fatigue protocol for contemporary dance. Med Probl Perform Art, 2006; 21: 65–70.

Dahlstrom PT, Inasio E, Kaijser L. Physical fitness effort in dancers: a comparison of four major dance styles. Impulse, 1996; 4: 193–209.

DanceSportInfo Rating system, 2012. Available from: http://dancesportinfo.net/DisplayTopCouples.aspx; Accessed 1 September 2011.

Del Balso C, Cafarelli E. Adaptations in the activation of human skeletal muscle induced by short-term isometric resistance training. J Appl Physiol, 2007; 103: 402–411.

Dolgener FA, Spasoff TC, St.John WE. Body build and body composition of high ability female dancers. RQES, 1980; 51: 599–607.

Duncan MJ, Woodfield L, al-Nakeeb Y. Anthropometric and physiological characteristics of junior elite volleyball players. Br J Sports Med, 2006; 40: 649–651.

Faulkner RA. Physique Characteristics of Canadian figure skaters. Simon Fraser University, Vancouver (Master thesis), 1976.

Franks IM, Goodman DA. Systematic approach to analyzing sports performance. J Sports Sci, 1986; 4: 49–59.

Gualdi-Russo E, Graziani I. Anthropometric somatotype of Italian sport participants. J Sports Med Phys Fitness, 1993; 33: 282–91.

Guidetti L, Emerenziani GP, Gallotta MC, Baldari C. Effect of warm up on energy cost and energy sources of a ballet dance exercise. Eur J Appl Physiol, 2007; 99: 275–281.

Hamilton L, Hamilton WG, Warren MP, Keller K, Molnar M. Factors contributing to the attrition rate in elite ballet students. J Dance Med Sci, 1997; 4: 131–138.

Hamilton LH, Brooks-Gunn J, Warren MP, Hamilton WG. The role of selectivity in the pathogenesis of eating problems in ballet dancers. Med Sci Sports Exerc, 1988; 20: 560–565.

Harley YXR, Gibson ASC, Harley EH, Lambert MI, Vaughan CL, Noakes TD. Quadriceps strength and jumping efficiency in dancers. J Dance Med Sci, 2002; 6: 87–94.

Hofmann P, Jürimäe T, Jürimäe J, Purge P, Mäestu J, Wonisch M, Pokan R, von Duvillard SP. HRTP, prolonged ergometer exercise, and single sculling. Int J Sports Med, 2007; 28: 964–969.

Hopper DM. Somatotype in high performance female netball players may influence player position and the incidence of lower limb and back injuries. Br J Sports Med, 1997; 31: 197–199.

Jensen K, Jørgensen S, Johansen L. Heart rate and blood lactate concentration during ballroom dancing. Med Sci Sports Exer, 2002; 34.

Jürimäe T, Sööt T, Jürimäe J. Relationships of anthropometrical parameters and body composition with bone mineral content or density in young women with different levels of physical activity. Physiol Anthropol Appl Human Sci, 2005; 24: 579–587.

Klonova A, Klonovs J, Giovanardi A, Cicchella A. The sport dance athlete: aerobic-anaerobic capacities and kinematics to improve the performance. Antropomotoryka, 2011; 55: 31–37.

Koutedakis Y, Hukam H, Metsios G, Nevill A, Giakas G, Jamurtas A, Myszkewycz L. The effects of three months of aerobic and strength training on selected performance and fitness-related parameters in modern dance students. J Strength Cond Res, 2007; 21: 808–812.

Koutedakis Y, Jamurtas A. The dancer as a performing athlete: physiological considerations. Sports Med, 2004; 34: 651–661.

Koutedakis Y, Sharp NCC. Thigh-muscles strength training, dance exercise, dynamometry, and anthropometry in professional ballerinas. J Strength Cond Res, 2004; 18: 714–718.

Langdon SW. Body image in dance and aesthetic sports. Encyclopedia of body image and human appearance. Elsevier, Oxford, 2012; 226–232.

Malina RM. Anthropometry and physical performance. In: Ulijaszek SJ, Mascie-Taylor CGN. (eds), Anthropometry: The individual and the population. Cambridge University Press, Cambridge, 1994; 141–159.

McCabe TR, Wyon M, Ambegaonkar JP, Redding E. A bibliographic review of medicine and science research in dancesport. Med Probl Perform Art, 2013; 28: 70–79.

Monsma EV, Malina RM. Anthropometry and somatotype of competitive female figure skaters 11–22 years. Variation by competitive level and discipline. J Sports Med Phys Fitness, 2005; 45: 491–500.

Monsma EV, Malina RM. Correlates of eating disorders risk among female figure skates: a profile of adolescent competitors. J. Sports Psychol, 2004; 5: 447–460.

Norton K, Olds T. Anthropometrica. UNSW Press, Sydney, 1996.

Oreb G, Ruzić L, Matkovic B, Misigoj-Durakovic M, Vlasic J, Ciliga D. Physical fitness, menstrual cycle disorders and smoking habit in Croatian National Ballet and National Folk Dance Ensembles. Coll Antropol, 2006; 30: 279–283.

Redding E, Wyon M. Strengths and weaknesses of current methods for evaluating the aerobic power of dancers. Dance Med Sci, 2003; 7: 10–16.

Schantz PG, Astrand PO. Physiological characteristics of classical ballet. Med Sci Sports Exerc, 1984; 16: 472–476.

Silva AH, Bonorino KC. BMI and flexibility in ballerinas of contemporary dance and classical ballet. Fit Perf J, 2008; 7: 48–51.

Tsunawake N, Tahara Y, Moji K, Muraki S, Minowa K, Yukawa K. Body composition and physical fitness of female volleyball and basketball players of the Japan inter-high school championship teams. J Physiol Anthropol Appl Human Sci, 2003; 22: 195–201.

Twitchett E, Angioi M, Metsios G, Koutedakis Y, Wyon M. Body composition and ballet injuries: a preliminary study. Med Probl Perform Art, 2008; 23: 93–98.

Twitchett E, Brodrick A, Nevill AM, Koutedakis Y, Angioi M, Wyon M. Does physical fitness affect injury occurrence and time loss due to injury in elite vocational ballet students? J Dance Med Sci, 2010; 14: 26–31.

WDSF Competition Rules (2011). World DanceSport Federation. Available from: http://www.worlddancesport.org/doc/competition/rules%20and%20bidding/2011/WDSF%20Competition%20Rules%202011.pdf (Accessed 23 February 2012).

WDSF DanceSport For All (2012) World DanceSport Federation. Available from: http://www.worlddancesport.org/About/All.

William J, Kraemer WJ, Ratamess N, Fry AC, Triplett-McBride T, Koziris LP, Bauer JA, Lynch JM, Fleck SJ. Influence of resistance training volume and periodization on physiological and performance adaptations in collegiate women tennis players. Am J Sports Med, 2000; 5: 626–633.

Wyon M, Koutedakis Y. Muscle fatigue: considerations for dance. J Dance Med, 2013; 17: 63–69.

Wyon MA, Deighan MA, Doherty M, Morrison SL, Allen N, Jobson SJ, George S. The cardiorespiratory, anthropometric, and performance characteristics of an international/national touring ballet company. J Strength Cond Res, 2007; 21: 389–393.

Wyon MA, Twitchett E, Angioi M, Clarke F, Metsios G, Koutedakis Y. Time motion and video analysis of classical ballet and contemporary dance performance. Int J Sports Med, 2011; 32: 851–855.

Yannakoulia M, Keramopoulos A, Tsakalakos N, Matalas AL. Body composition in dancers: the bioelectrical impedance method. Med Sci Sports Exerc, 2000; 32: 228 – 234.

SUMMARY IN ESTONIAN

Antropomeetrilised näitajad, keha koostis ja aeroobne vastupidavus eliittasemel tantsusportlastel võrreldes balletitantsijate ja moderntantsu tantsijatega

SISSEJUHATUS

Tantsusport on spordiala, mis on välja kujunenud seltskonnatantsudest, mida tantsitakse paaris. Võisteldakse kolmes erinevas distsipliinis: standardtantsud, Ladina-Ameerika tantsud ja kümme tantsu. Standardtantse on viis: aeglane valss, tango, Viini valss, fokstrott ja kvikstep. Ladina-Ameerika tantse on samuti viis: samba, tšatša, rumba, pasodoobel ja džaiv. Kümne tantsu distsipliini moodustavad viis standardtantsu ja viis Ladina-Ameerika tantsu. Tantsuspordi võistluspäev koosneb voorudest. Viimasesse vooru jõudnud paarid võistlevad esikohale. Selleks hetkeks on nad tantsinud mitmeid voore, teinud kokku u 5–20 sooritust. Iga sooritus on 90–120 sekundit pikk. Kohtunikud hindavad tantsupaaride puhul nii esteetilist esitust, koreograafiat, musikaalsust kui ka kehalist võimekust tantsude sooritamisel.

Spordialadele on omased teatud antropomeetrilised eripärad ja kehakuju. Esteetilistel spordialadel nagu iluvõimlemine, iluuisutamine ja tantsusport esitatakse kehakujule ja antropomeetriale spetsiifilisi nõudmisi nii sportliku soorituse kontekstis kui ka esteetilistel kaalutlustel.

Samuti nagu mõiste sport katab paljusid erinevaid spordialasid, hõlmab mõiste tants mitmeid erinevaid tantsustiile. Uurimused, mis kajastavad balleti- või moderntantsu tantsijate aeroobset võimekust, antropomeetriat ja keha koostist, ei pruugi kehtida tantsusportlaste kohta ja vastupidi.

UURIMISTÖÖ EESMÄRK JA ÜLESANDED

Töö eesmärk on uurida rahvusvahelisel tasemel võistlevate tantsusportlaste antropomeetrilisi parameetreid, somatotüüpi, keha koostist ja aeroobse võimekuse taset ning nende näitajate seost soo, tantsuliigi (standardtantsud, Ladina-Ameerika tantsud ja kümme tantsu), rahvusvahelise karikasarja koondtabeli tulemuste ja teiste tantsustiilidega (klassikaline ballett ja moderntants). Lähtuvalt eesmärgist on uurimistöö ülesanneteks:

1. uurida, kas erinevate tantsuspordi tantsuliikide tantsijad erinevad antropomeetriliste parameetrite ja somatotüübi osas ja kas antud parameetritel on seos rahvusvahelise karikasarja koondtabeli positsiooniga;
2. uurida rahvusvahelisel tasemel võistlevate tantsusportlaste aeroobset võimekust laboratoorsetes tingimustes ja võistlussimulatsiooni käigus ning analüüsida aeroobse võimekuse seost soo, tantsuliigi ja rahvusvahelise karikasarja koondtabeli tulemusega;

3. võrrelda erinevate tantsustiilide (tantsuspordi, klassikalise balleti ja moderntantsu) tantsijate antropomeetrilisi parameetreid, keha koostist, somatotüüpi ja aeroobset võimekust.

UURITAVAD JA METOODIKA

Uuritavad

Uuringus osales 286 tantsijat kolmest tantsustiilist: 60 tantsusportlast (30 meest ja 30 naist), 89 balletitantsijat (33 meest ja 56 naist) ja 137 moderntantsu tantsijat (28 meest ja 109 naist). Tantsusportlased kuulusid rahvusvahelise karikasarja tabelis esimese 6% hulka ja jagunesid omakorda 12 standardtantsu, 7 Ladina-Ameerika tantsu ja 11 kümne tantsu paariks. Tantsusportlaste keskmine treeningstaaž oli 14,9 ± 5,1 aastat. Balleti- ja moderntantsu tantsijate puhul oli tegemist elukutseliste tantsijatega.

Antropomeetria, somatotüüp ja keha koostis

Antropomeetrilised parameetrid (pikkus, keha mass, KMI) mõõdeti kõigil osalejatel. Keha rasvaprotsent ja somatotüüp määrati 49 balletitantsijal (mehed: n = 16, naised: n = 33), 118 moderntantsu tantsijal (21 meest ja 97 naist) ja 60 tantsusportlasest uuritaval (30 meest ja 30 naist).

Antropomeetriliste parameetrite mõõtmiseks kasutati ISAKi (Norton & Olds, 1996) metoodikat. Kolm somatotüübi komponenti – endomorfsus, mesomorfsus ja ektomorfsus – arvutati vastavalt Heath-Carter metoodikale (Carter & Heath 1990). Keha koostise määramiseks kasutati DXA meetodit, mille abil leiti keha rasvaprotsent.

Aeroobne võimekus

Aeroobne võimekus mõõdeti 40 balletitantsijal (17 meest ja 23 naist), 19 moderntantsu tantsijal (7 meest ja 12 naist) ja 60 tantsusportlasel (30 meest ja 30 naist).

Maksimaalset aeroobset võimekust mõõdeti jooksulindil maksimaalse suutlikkuseni. Uuringus osalejad läbisid 5minutise soojenduse (mehed kiirusega 7 km/h ja naised kiirusega 5 km/h). Koormustest algas meestel kiirusega 8 km/h ja naistel kiirusega 6 km/h. Jooksulindi tõusunurk oli 0%. Kiirust tõsteti iga 2 minuti järel 1 km võrra tunnis. Testimise käigus mõõdeti maksimaalne hapniku tarbimine, südame löögisagedus ja vere laktaadi kontsentratsioon kapillaarveres.

Võistlussimulatsioon tantsusportlastel

Kõik tantsusportlased osalesid võistlussimulatsioonil. Standardtantsude ja Ladina-Ameerika tantsude tantsijad sooritasid kolmevoorulise võistlussimulatsiooni (kokku 15 tantsu), kus igas voorus tuli tantsida 5 tantsu. Kümne tantsu tantsijad sooritasid kahevoorulise simulatsiooni (kokku 20 tantsu), kus kummaski voorus tuli tantsida 10 tantsu. Tantsude ja pauside pikkus oli reguleeritud vastavalt WDSFi reeglitele (*WDSF Competition Rules*, 2011). Võistlus-simulatsiooni käigus mõõdeti südame löögisagedus ja laktaadi kontsentratsioon kapillaarveres tantsuvoorude järgselt.

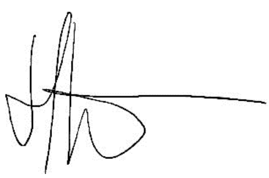
JÄRELDUSED

1. Lihaselisema kehaehitusega standardtantsude tantsijad on rahvusvahelise karikasarja koondtabelis kõrgematel kohtadel. Standardtantsude tantsijatel on võrreldes Ladina- Ameerika tantsude tantsijatega pikem käte siruulatus ja istepikkus. Kümne tantsu tantsijate keha proportsioonid ei erine standard-tantsude ja Ladina-Ameerika tantsude tantsijate omadest. Standardtantsude tantsijad on võrreldes Ladina-Ameerika tantsijatega ektomorfsema keha-ehitusega, suurema kasvu, käte siruulatuse ja istekõrgusega. Kuigi standard-tantsude tantsijad olid ektomorfsema kehaehitusega, siis need tantsijad, kellel oli kõrgem mesomorfsuse näitaja olid rahvusvahelise karikasarja koondtabelis kõrgematel positsioonidel.
2. Kõigi kolme tantsuspordiliigi (standard-, Ladina-Ameerika ja kümne tantsu) rahvusvahelisel tasemel võistlevate tantsusportlaste aeroobne võimekus on suhteliselt kõrge ja ei erine statistiliselt oluliselt üksteisest. Ladina-Ameerika tantsude tantsusoorituse intensiivsus on võrreldes standardtantsude soorituse intensiivsusega oluliselt kõrgem. Eriti suur on soorituse intensiivsuse erinevus naistantsijate võrdluses. Rahvusvahelise karikasarja koondtabeli ja aeroobse võimekuse vahel seost ei leitud.
3. Tantsusportlased on võrreldes balletitantsijate ja moderntantsu tantsijatega suurema keha massiga ja vähem lihaselised. Kolme tantsustiili (balleti, moderntantsu ja tantsuspordi) võrdluses on balletitantsijad väikseima keha massi, kehamassiindeksi ja rasvaprotsendiga. Balletitantsijad, moderntantsu tantsijad ja tantsusportlased erinevad mõningal määral antropomeetriliste parameetrite, somatotüübi ja aeroobse võimekuse osas.

ACKNOWLEDGEMENTS

I would like to thank my academic supervisors Professor Dr Toivo Jürimäe, Professor Dr Jaak Jürimäe and Senior Lecturer Dr Jarek Mäestu, for all of their advice and support throughout the writing process; all of the dancers who were kind enough to participate in the study; Dr Priit Purge and Dr Meeli Saar, for helping me collect data; Dr Katre Maasalu and Maive Margus, for conducting DXA analyses; Professor Dr Matthew Wyon, for advice and support and for the chance to collaborate with the University of Wolverhampton; my dance teachers Peep and Ave Vardja, for introducing me to the magic of DanceSport; my dance partner Veiko Ratas, for the experience we have shared during our many years of dancing together; my parents, for their endless encouragement and support; and most of all Karl, for being there for me.

I am grateful to everyone who has supported and inspired me during my doctoral studies.



Helena Liiv,
Tartu 2014

PUBLICATIONS

CURRICULUM VITAE

Name:	Helena Liiv
Date of birth:	6.12.1983
Citizenship:	Estonian
E-mail:	liivhelena@gmail.com

Educational career:

2009–2014	Doctoral study, Faculty of Exercise and Sport Sciences, University of Tartu, Estonia
2010 –2013	BSc, Faculty of Law, University of Tartu, Estonia
2012–2012	University of Wolverhampton, Research Centre for Sport Exercise and Performance, exchange doctoral student (research and study visit)
2011–2011	University of Bologna, Faculty of Exercise and Sport Sciences, Department of Psychology, exchange doctoral student
2007–2009	MSc, Faculty of Exercise and Sport Sciences, University of Tartu, Estonia
2003–2007	BSc, Faculty of Exercise and Sport Sciences, University of Tartu, Estonia
2000–2003	Tartu Hugo Treffner Gymnasium
1990–2000	Tartu Descartes Lyceum

Professional career:

2006–2008	Instructor, Faculty of Exercise and Sport Sciences, University of Tartu, Estonia
2005 onwards	Dance School Tango, DanceSport teacher

ELULOOKIRJELDUS

Nimi:	Helena Liiv
Sünniaeg:	06.12.1983
Kodakondsus:	Eesti
E-mail:	liivhelena@gmail.com

Haridustee

2009–2014	Doktoriõpe, Tartu Ülikool kehakultuuriteaduskond
2010–2013	Bakalaureuseõpe, Tartu Ülikool õigusteaduskond
2012–2012	Wolverhamptoni Ülikool, Sporditeaduste uurimiskeskus, stipendiaat
2011–2011	Bologna Ülikool, kehakultuuriteaduskond, stipendiaat
2007–2009	Magistriõpe, Tartu Ülikool kehakultuuriteaduskond
2003–2007	Bakalaureuseõpe, Tartu Ülikool kehakultuuriteaduskond
2000–2003	Tartu Hugo Treffneri Gümnaasium
1990–2000	Tartu Descartes'i Lütseum

Töökogemus

2006–2008	Õppeülesande täitja Tartu Ülikoolis kehakultuuriteadukonnas
Alates 2005	Tantsukool Tango, tantsuspordi treener

DISSERTATIONES KINESIOLOGIAE UNIVERSITATIS TARTUENSIS

1. **Lennart Raudsepp.** Physical activity, somatic characteristics, fitness and motor skill development in prepubertal children. Tartu, 1996, 138 p.
2. **Vello Hein.** Joint mobility in trunk forward flexion: methods and evaluation. Tartu, 1998, 107 p.
3. **Leila Oja.** Physical development and school readiness of children in transition from preschool to school. Tartu, 2002, 147 p.
4. **Helena Gapeyeva.** Knee extensor muscle function after arthroscopic partial meniscectomy. Tartu, 2002, 113 p.
5. **Roomet Viira.** Physical activity, ecological system model determinants and physical self-perception profile in early adolescence. Tartu, 2003, 167 p.
6. **Ando Pehme.** Effect of mechanical loading and ageing on myosin heavy chain turnover rate in fast-twitch skeletal muscle. Tartu, 2004, 121 p.
7. **Priit Kaasik.** Composition and turnover of myofibrillar proteins in volume — overtrained and glucocorticoid caused myopathic skeletal muscle. Tartu, 2004, 123 p.
8. **Jarek Mäestu.** The perceived recovery-stress state and selected hormonal markers of training stress in highly trained male rowers. Tartu, 2004, 109 p.
9. **Karin Alev.** Difference between myosin light and heavy chain isoforms patterns in fast- and slow-twitch skeletal muscle: effect of endurance training. Tartu, 2005, 117 p.
10. **Kristjan Kais.** Precompetitive state anxiety, self-confidence and ahtletic performance in volleyball and basketball players. Tartu, 2005, 99 p.
11. **Aire Leppik.** Changes in anthropometry, somatotype and body composition during puberty: a longitudinal study. Tartu, 2005, 161 p.
12. **Jaan Ereline.** Contractile properties of human skeletal muscles: Association with sports training, fatigue and posttetanic potentiation. Tartu, 2006, 133 p.
13. **Andre Koka.** The role of perceived teacher feedback and perceived learning environment on intrinsic motivation in physical education. Tartu, 2006, 137 p.
14. **Priit Purge.** Performance, mood state and selected hormonal parameters during the rowing season in elite male rowers. Tartu, 2006, 101 p.
15. **Saima Kuu.** Age-related contractile changes in plantarflexor muscles in women: associations with postactivation potentiation and recreational physical activity. Tartu, 2006, 101 p.
16. **Raivo Puhke.** Adaptive changes of myosin isoforms in response to long-term strength training in skeletal muscle of middle-aged persons. Tartu, 2006, 99 p.

17. **Eva-Maria Riso.** The effect of glucocorticoid myopathy, unloading and reloading on the skeletal muscle contractile apparatus and extracellular matrix. Tartu, 2007, 114 p.
18. **Terje Sööt.** Bone mineral values in young females with different physical activity patterns: association with body composition, leg strength and selected hormonal parameters. Tartu, 2007, 94 p.
19. **Karin Tammik.** Neuromuscular function in children with spastic diplegic cerebral palsy. Tartu, 2007, 102 p.
20. **Meeli Saar.** The relationships between anthropometry, physical activity and motor ability in 10–17-year-olds. Tartu, 2008, 96 p.
21. **Triin Pomerants.** Ghrelin concentration in boys at different pubertal stages: relationships with growth factors, bone mineral density and physical activity. Tartu, 2008, 80 p.
22. **Tatjana Kums.** Musculo-skeletal function in young gymnasts: association with training loads and low-back pain. Tartu, 2008, 128 p.
23. **Maret Pihu.** The components of social-cognitive models of motivation in predicting physical activity behaviour among school students. Tartu, 2009, 116 p.
24. **Peep Päll.** Physical activity and motor skill development in children. Tartu, 2009, 102 p.
25. **Milvi Visnapuu.** Relationships of anthropometrical characteristics with basic and specific motor abilities in young handball players. Tartu, 2009, 114 p.
26. **Rita Gruodytė.** Relationships between bone parameters, jumping height and hormonal indices in adolescent female athletes. Tartu, 2010, 82 p.
27. **Ragnar Viir.** The effect of different body positions and of water immersion on the mechanical characteristics of passive skeletal muscle. Tartu, 2010, 142 p.
28. **Iti Müürsepp.** Sensorimotor and social functioning in children with developmental speech and language disorders. Tartu, 2011, 90 p.
29. **Ege Johanson.** Back extensor muscle fatigability and postural control in people with low back pain. Tartu, 2011, 106 p.
30. **Evelin Lätt.** Selected anthropometrical, physiological and biomechanical parameters as predictors of swimming performance in young swimmers. Tartu, 2011, 90 p.
31. **Raul Rämson.** Adaptation of selected blood biochemical stress and energy turnover markers to different training regimens in highly trained male rowers. Tartu, 2011, 84 p.
32. **Helen Jõesaar.** The effects of perceived peer motivational climate, autonomy support from coach, basic need satisfaction, and intrinsic motivation on persistence in sport. Tartu, 2012, 108 p.
33. **Sille Vaiksaar.** Effect of menstrual cycle phase and oral contraceptive use on selected performance parameters in female rowers. Tartu, 2012, 86 p.

34. **Anna-Liisa Parm.** Bone mineralization in rhythmic gymnasts before puberty: associations with selected anthropometrical, body compositional and hormonal parameters. Tartu, 2012, 96 p.
35. **Jelena Sokk.** Shoulder function in patients with frozen shoulder syndrome: the effect of conservative treatment and manipulation under general anaesthesia. Tartu, 2012, 125 p.