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Contents

EFFECTS OF EXERCISE ON APPETITE-REGULATING HORMONES, PERCEIVED HUNGER, AND ENERGY INTAKE: A NARRATIVE OVERVIEW

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Abstract Controlling appetite, perceived hunger, and energy intake are important factors in weight management. This narrative review examines the effect of different forms, intensities and duration of exercise on the appetite-regulating hormones leptin, acylated ghrelin, glucagon like peptide-1 (GLP-1) and peptide tyrosine tyrosine$_{3\text{-}36}$ (PYY$_{3\text{-}36}$), perceptions of hunger, and energy intake in overweight/obese, and normal weight populations. The studies reviewed compared exercise intensities- low, moderate, and high intensity, and modes of exercise- aerobic and resistance training. The studies selected in this narrative review included participants that ranged in age from 13–57 years old, male and female, previously sedentary and physically active, and normal weight and overweight/obese individuals- defined by body mass index standards (BMI). The primary benefits of exercise on appetite regulation are seen with moderate to high-intensity aerobic exercise; with the most notable relative energy deficit resulting from an exercise bout (at any intensity) that expends the most energy. Further research is warranted to determine if there exists a tendency to overcompensate for energy expended during exercise in certain populations.

Key words Exercise, Appetite regulation, Hunger, Weight management

Introduction

Creating an energy deficit is essential for weight loss. However, increasing exercise and therefore, energy expenditure, does not always result in desired weight loss. In a recent review, Caudwell, Gibbons, Finlayson, Naslund, and Blundell (2013) reported that, although the research predominantly shows an acute bout of exercise does not create an increase in hunger, desire to eat, or energy intake, when exercise is extended over a few days and caloric intake is monitored for a longer period, partial compensation for increased energy expenditure can occur. In these cases, even though individuals are increasing physical activity, they are subsequently increasing

caloric intake thereby undermining their own weight loss efforts. High-intensity exercise is correlated with a transient reduction in hunger that may be due to a temporary decrease in the active component of the appetite-stimulating hormone ghrelin (Caudwell et al., 2013). The appetite-regulating hormones acylated ghrelin, leptin, GLP-1, and PYY_{3-36} are recognized to be a major influence on energy homeostasis (Klok, Jakobsdottir, Drent, 2007). Ghrelin has an appetite stimulating effect, whereas increases in leptin, GLP-1, and PYY_{3-36} tend to have appetite-suppressing effects, except in cases of leptin resistance in which increased levels of leptin do not correlate with appetite-suppression. These hormones respond differently to varying exercise modes (cardiovascular and resistance training), intensities, and duration (Caudwell et al., 2013; Klok et al., 2007). The purpose of this narrative review is to examine and describe the current evidence on the effect different exercise forms (cardiovascular and resistance training), intensities, and duration of exercise has on appetite-regulating hormones (leptin, acylated ghrelin, GLP-1, and PYY_{3-36}), perceptions of hunger, and energy intake in overweight/obese, and normal weight populations.

Methods

Nine academic electronic databases were used in the narrative search: PubMed; Scopus; ProQuest; EBSCOhost; SpringerLink; ArticleFirst; Taylor & Francis; Wiley Online; and ScienceDirect. The academic databases were selected based of their academic rigor, aim, biomedical scope and accessibility. A combination of search terms included 'exercise, 'physical activity', high intensity exercise', 'low intensity exercise', strength training', 'gender', 'appetite-regulating hormones, 'hunger', 'energy intake', 'overweight', obesity', 'weight management', 'leptin', 'acylated ghrelin', 'GLP-1', and 'PYY_{3-36}'. References from retrieved articles were reviewed to identify additional relevant publications for the years 2007 through October 2017. The results generated by the search were limited to the English language. Publications were reviewed for relevance to the topic. References from retrieved articles were reviewed to identify additional applicable publications.

Discussion

Low-Intensity Aerobic Exercise

In researching the effects of low-intensity exercise on appetite-regulating hormones, King, Wasse, Broom, and Stensel (2010) found that although a 60-minute brisk walk in healthy adult males resulted in a moderate energy deficit, it had no effect on appetite, acylated ghrelin, or energy intake. Similar results were found for healthy adults cycling for a short duration (30-minutes) at a low-intensity (below the aerobic-anaerobic threshold); the exercise had no effect on hunger/satiety sensations or on subsequent energy intake (Erdmann, Tahbaz, Lippl, Wagenpfeil, Schusdziarra, 2007). Low-intensity exercise, such as walking, gentle yoga, tai chi, and stretching have many positive health benefits including modest energy expenditure which can aid in weight management; however, it is unlikely to result in the appetite-reducing effects that have been seen with higher-intensity exercise.

Moderate and High-Intensity Aerobic Exercise

Moderate and high-intensity exercise has appetite reducing effects that may be beneficial for those looking to improve body composition. High-intensity exercise has a more notable acute-effect on appetite suppression than moderate-intensity exercise; however, the effects on appetite may be just as notable with moderate-intensity exercise

in the hours after. In a comparison of high-intensity cycling bouts (10, 4-min cycling bouts at 85–90% VO_2max), to steady-state moderate aerobic exercise (60-min cycling at 60% VO_2max), there was greater appetite suppression during the high-intensity cycling (Deighton, Karra, Batterham, Stensel, 2013); the authors, however, found that both exercise intensities suppressed appetite over the 8-hour trial, with no statistically significant differences. There was an increase in PYY_{3-36} immediately after the steady-state exercise, however PYY_{3-36} was higher in the hours after high-intensity training. Despite the minor differences in PYY_{3-36}, both exercise intensities were effective at inducing an energy deficit without compensation of energy intake following exercise. Similar results were found in physically active women; Howe et al. (2016) compared isocaloric bouts (expending about 500 kcal per exercise session) of moderate-intensity (60% VO_2max) and high-intensity (85% VO_2max) exercise. Although there were no differences in appetite hormones following exercise between-high and moderate intensities, there was a significant main effect for time. Immediately after exercise GLP-1 and PYY_{3-36} were significantly higher than at baseline (before exercise), and ghrelin was significantly lower; however, 60-minutes after exercise all three hormones were at levels close to baseline. Appetite ratings were higher at 60-minutes post-exercise with both exercise intensities with no significant differences.

In trained long-distance male runners, there were surprisingly no changes to PYY immediately after a 78-minute run at 78% HRmax, the authors suggest this may be a result of an overnight fast prior to exercise; whereas in previous studies showing a rise in PYY the participants consumed a pre-exercise meal (Kojima, Ishibashi, Ebi, Goto, 2016). Despite no significant changes in PYY, the trained long-distance runners did report significantly lower appetite ratings and had significantly lower absolute energy intake immediately after exercise (and up to 60-minutes post-exercise), compared to a non-exercise day (Kojima et al., 2016).

These results show that despite the immediate appetite-suppressing effects of an exercise, the energy expended during the exercise session had a more notable effect on relative energy intake (calories expended during the exercise minus the calories consumed after the exercise). Deighton, Barry, Connon, and Stensel (2013) compared sprint intervals (6, 30-second Wingate tests) to a 60-minute bout of moderate-intensity steady-state cycling (at 68% VO_2max) and found that although acylated ghrelin was lowest during and after the sprint-intervals, the relative energy intake was lower with the endurance exercise trial. This was due to the greater energy expenditure during the longer bout of steady-state cycling without subsequent overcompensation of energy intake following the exercise session.

Douglas et al. (2015) found that two consecutive days of moderate-intensity exercise (60-minute treadmill run at 70% of VO_2peak) in healthy-young men resulted in a significant suppression of perceived hunger and significantly elevated PYY over both days of the exercise trial when compared to 2-days of no exercise; there was also significantly lower relative energy intake over the 2-days of exercise compared to the non-exercise days.

Resistance Training

There has been limited research into the potential effects of resistance training on appetite-regulating hormones, hunger, and subsequent energy intake. Guelfi, Donges, and Duffield (2013) compared the effects of 12-weeks of moderate-intensity aerobic exercise to resistance training and found an increase in perceived fullness following a meal in the aerobic exercise group with no other statistically significant differences between hunger ratings or appetite-regulating hormones. According to Broom et al. (2009), resistance exercise suppresses hunger to up to one hour compared with no exercise; however, this response is less influential than aerobic exercise.

In a subsequent study, Laan, Leidy, Lim, and Wayne (2010) looked at the meal energy intake following resistance exercise, compared to aerobic exercise, and found no differences in energy intake during the meal following exercise. The aerobic exercise, however, resulted in greater energy expenditure, and therefore a lower energy intake relative to energy expended in the meal following exercise. The resistance exercise did have a relative energy intake lower compared to no exercise. These results suggest that the amount of energy expended during exercise is more significant, for weight loss purposes, than the effects of appetite regulating hormones of either aerobic or resistance training (Lann et al., 2010). Aerobic exercise, which can be sustained for an extended period-of-time, typically results in greater energy expenditure; this, in addition to the appetite-suppressing effects immediately post-moderate/high intensity aerobic exercise, provide a better option for reducing relative energy intake for individuals trying to lose weight.

Gender Differences

There are varying results when it comes to the appetite-suppressing effects of exercise between genders. Hagobian et al. (2009) found differences in appetite-regulating hormones between men and women after moderate-intensity exercise (50–65% VO_2max until 30% of total daily energy expenditure expended). The comparisons were made in overweight men and women, and found that for women only, acylated ghrelin levels, in addition to appetite ratings, were increased after exercise. The authors suggested their findings may help explain why when previously sedentary men and women follow exercise training programs with ad libitum feeding, men typically lose body fat, but women do not (Hagobian et al., 2009). In contrast, Hagobian et al. (2013) compared the effects of exercise and appetite control in normal weight, active men and women and found acute exercise (cycling at 70% VO_2max until 30% of total daily energy expenditure was expended) effectively suppresses short-term appetite regardless of gender. Overweight and obese women may not benefit from the appetite-suppressing effects of low to moderate-intensity exercise when compared to normal weight individuals and overweight men. What was noteworthy between the two studies is the level of exercise intensity; in the study showing increased hunger and ghrelin levels after overweight women exercised (Hagobian et al., 2009), the exercise intensity was set between 50–65% VO_2max. When compared to Hagobian et al., 2013 in which the exercise intensity was consistent moderate-intensity at 70% VO_2max, it is possible that an exercise intensity fluctuating between low to moderate-intensity (Hagobian et al., 2009) is not sufficient to produce any appetite-suppressing effects. According to Vantansever-Ozen, Tiryaki-Sonmez, Bugdayci, and Ozen (2011), a minimum exercise intensity of at least 60% VO_2max is likely necessary to have any effect on appetite-regulating hormones.

There is insufficient evidence to suggest women are disadvantaged when using exercise to suppress appetite-hormones and perceived hunger after exercise at an intensity of at least 60% VO_2max. It is important to note that both referenced studies comparing men and women controlled for the menstrual phase of the women participating; women participated during the early follicular phase of menstruation (1–4 days after menstruation). It is generally accepted that women tend to increase their energy intake during the luteal phase of menstruation compared to the follicular phase (Campolier et al., 2016), therefore if not controlled for, menstruation could confound the results of a study comparing appetite hormones in women.

Overweight/Obesity, Exercise, and Appetite Regulation

Individuals looking to lose weight stand to gain major benefits from the potential effect exercise has on appetite-regulating hormones. When overweight/obese individuals, male and female, exercise at intensities above 60% VO_2max, there are beneficial short- and long-term changes to appetite-regulating hormones, perceived hunger, and relative energy intake. Martins et al. (2015) found obese individuals to have appetite-suppressing benefits of moderate-and high-intensities, similar to that of normal weight individuals, with no significant differences between intensities. Steady-state cycling at 70% HRmax (to expend 250 calories) had similar short-term appetite-suppressing effects as sprint-intervals which raised heart rate intermittently to 85–90% HRmax (also to expend 250 calories). There were beneficial effects of both exercise intensities on appetite-hormones, perceived hunger, and relative energy intake over non-exercise, with no statistically significant differences between moderate- or high-intensity exercise. In a comparison of lean vs overweight/obese individuals exercising for 60-minutes at moderate to low intensities (60 and 58% VO_2peak respectively), there were only small differences in appetite, relative energy intake, and appetite-regulating hormone concentrations between the two groups over the 8-hour trial. Regardless of BMI, there was a suppression of appetite immediately after exercise, and an increase of PYY and GLP-1 in the hours after exercise. There were no changes to acylated ghrelin in response to exercise in either group which may be a result of the VO_2peak being too low (59% peak VO_2) to elicit a change in acylated ghrelin (Douglas et al., 2017). Therefore, based on the aforementioned authors, if the exerciser has reached a moderate-high intensity there will be a short-term appetite-suppressing effect on appetite.

In a 12-week study comparing low-and high-intensity exercise in obese adolescents (13–18 years-old); both groups exercised 3 days/week expending 350 calories each exercise session. The high-intensity exercise group saw increases in PYY_{3-36}, and reduced energy intake based on 24-hour food logs (it is important to note that energy intake was not assessed daily over the 12-weeks) (Prado et al., 2015). In addition to measuring the effects exercise has on appetite, the researchers also monitored body composition over the 12-week period. Both exercise therapies were effective at reducing body mass, BMI, fat mass, and increasing fat free mass, with no significant differences between groups. It is important to note that both groups received multidisciplinary treatment including nutrition and psychological counseling over the 12-weeks. Counseling and subsequent awareness of dietary behaviors could be an explanation for why, despite more significant appetite-suppressing effects in the high-intensity exercise group, both groups had similar improvements in body composition.

Conclusions

It is estimated that 70% of adults in the United States are overweight or obese and the prevalence of obesity among adolescents age 12–19 years old is continuing to increase with one in five adolescents considered obese-these statistics are estimated from 2013–2014 National Health and Nutrition Examination Survey (Fryar, Carrol, Ogden, 2016). Overweight and obesity increases the risk of developing chronic health diseases such as diabetes and heart disease which is good reason for a growing interest in studying the role that appetite-regulating hormones such as leptin, ghrelin, and PYY_{3-36}, have on overeating, and subsequently weight management. The studies reviewed suggest a positive correlation between moderate to high-intensity exercise and appetite suppression through changes in appetite-regulating hormones, perceived hunger, and relative energy intake.

In this narrative review, exercise intensities were differentiated based on levels of maximal oxygen uptake (VO_2max) or maximum heart rate (HRmax) with low-intensity exercise at a VO_2max below 60%, moderate-intensity exercise a VO_2max or HRmax between 60–85%, and high-intensity exercise a VO_2max or HRmax 85% and above. The studies selected in this review included participants that ranged in age from 13–57 years old, male and female, previously sedentary and physically active, and normal weight and overweight/obese individuals- defined by body mass index standards (BMI). Many of the studies included in this review measured perceived hunger which was assessed using 100 m visual analogue scales with descriptors anchored at each end; the assessment calculated an overall appetite score to include hunger, satisfaction, fullness, and prospective food consumption.

Low-intensity exercise, below 60% VO_2max, has little-to-no effect on appetite-regulating hormones, perceived hunger or energy intake; although it does create a modest energy deficit (King et al., 2010) that would likely benefit those making an-effort to lose weight. Moderate and high-intensity aerobic exercise above 60% VO_2max – whether steady-state or sprint-intervals – show the most promise in suppressing appetite (Howe et al., 2016). Resistance exercise has some short-term appetite-reducing effects (Broom et al., 2009); however, the longer-term effects are not well studied, and aerobic exercise (steady-state or sprint-intervals) is more likely to create a relative energy deficit; an important factor in weight reduction.

There were varying results in comparing exercise and appetite-suppression between genders; overweight/obese women may not have similar benefits of appetite suppression with exercise compared to overweight/obese men. Although these differences were only found with exercise intensity of 50–65% (Hagobian et al., 2009), an exercise intensity of at least 60% VO_2max is likely necessary to have any effect on appetite-regulating hormones (Vantansever-Ozen et al., 2011).

Further research is needed to determine the effects of exercise on appetite in overweight/obese women, including variations between phases of the menstrual cycle. Overweight/obese individuals, who stand to gain the most from any changes that exercise has on appetite and relative energy intake, have been shown to have positive changes to appetite with exercise. The exercise can be moderate to high intensity, as-long as it is over 60% VO_2max, it can be steady-state exercise or sprint-intervals. This narrative review did not find evidence to support the theory that individuals overcompensate for energy expended by consuming more after exercise; although it is important to note that the participants of all the studies reviewed were aware that they were being monitored and there is the possibility of bias affecting their energy intake following exercise. In summary, moderate to high-intensity exercise affects appetite-regulating hormones and perceived hunger leading to reduced relative energy intake. Understanding how exercise affects appetite-regulating hormones will help fitness, nutrition, health, and wellness professionals tailor exercise and dietary recommendations to an individual.

Clinical Implications

For nutrition and health professionals working with overweight/obese clients; developing a regular exercise routine including moderate to high-intensity aerobic exercise should be a goal to help regulate appetite hormones, reduce perceived hunger, and create an energy deficit. For substantial health benefits, the United States Department of Health and Human Services recommend adults include physical activity in the amounts of 150–300 minutes of moderate-intensity exercise per week or 75–150 minutes of vigorous-intensity exercise per week, in addition to strength training two or more days per week; it is advised that children and adolescents do 60-minutes or more of physical activity per day (Centers for Disease Control and Prevention, 2016). Physical activity should not be

discouraged out of a fear of energy overcompensation. For previously sedentary individuals or those with injuries limiting activity, even low-intensity exercise can create a modest energy deficit (King et al., 2010). Regulating appetite is one factor in achieving weight loss; clinicians should be aware of the potential benefits of a multidisciplinary approach to weight loss, including athletic training, nutrition counseling, and behavioral therapy.

Limitations

The focus of this review was on the potential benefits that exercise can have on appetite regulation in overweight/obese individuals. Potential negative effects of other populations of interest should be noted; athletes – especially those looking to gain lean body mass should be aware of the appetite suppressing effects immediately after moderate and high-intensity aerobic exercise and resistance training given that optimal fueling for recovery includes a post-meal snack or meal within 30-minutes of exercise. Another population that should take note are those recovering from eating disorders in which appetite-suppression would not be a desired effect. Another limitation worth mentioning is that the authors did not distinguish between the hormonal and biochemical response to different kinds of exercise based on age, gender, activity, physical performance, body composition, initial hormonal status and other relevant factors. Given that narrative reviews are considered among the lowest levels of evidence-based research, tend to be mainly descriptive in nature, and can often include an element of selection bias, some level of caution should be considered regarding its conclusions.

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DIFFERENCES IN PHYSIOLOGICAL INFLUENCES ON HEART RATE RECOVERY BETWEEN TRAINED AND UNTRAINED ADULTS

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Abstract The purpose of this study was to evaluate differences in heart rate recovery (HRr) in trained and untrained adults, while assessing the role of physiological and emotional factors. Eighteen untrained and 21 trained participants completed a maximal exercise test and a 20-min treadmill exercise at 55–70% heart rate reserve, and emotional state was assessed prior to exercise. Multiple regression was used to assess relationships between heart rate recovery and physiological and emotional assessments. The trained group had a higher relative maximal oxygen consumption ($p < 0.001$), lower resting heart rate ($p < 0.001$), and faster short- and long-term heart rate recovery ($p < 0.05$) than the untrained group. Resting heart rate was the most predictive measure with HRr for the trained group ($R = 0.551–0.818$), whereas resting heart rate, maximal heart rate, and fitness were predictors of recovery in the untrained group ($R = 0.764–0.977$). The results show the predominant parasympathetic influence on HRr in the trained group, but indicates influence of fitness and exercise intensity on recovery in the untrained group. Thus, fitness appears to influence HRr in those only with low fitness. This notion may help influence the behavior of untrained individuals to improve fitness to reduce risk of mortality and morbidity.

Key words aerobic fitness, cardiovascular, cardiorespiratory, health

Introduction

Heart rate recovery (HRr) is a measure of parasympathetic response to exercise and is modifiable with aerobic training (Kokkinos et al., 2012; Matsuo et al., 2014). Onset of exercise increases sympathetic activation, which increases heart rate (HR) with consideration to exercise demand (Pierpont, Adabag, Yannopoulos, 2013), and parasympathetic reactivation occurs at the cessation of exercise and reduces HR back to resting levels. Although not entirely understood, the influence of parasympathetic reactivation is supported by the physiological response of plasma norepinephrine that peaks approximately one to two minute post-exercise (Pierpont et al., 2013). HRr is utilized as a prognostic indicator of mortality risk, with a delayed parasympathetic response indicating higher

risk (Kokkinos et al., 2012). Disease, deconditioning, and body composition are believed to contribute to delayed responses, with severity of disease or deconditioning correlating to higher risk (Kokkinos et al., 2012; Matsuo et al., 2014; Pierpont et al., 2013).

Research has shown that HRr is predictable among healthy children (Singh, Rhodes, Gauvreau, 2008) and adults, with higher body composition and decreased aerobic capacity corresponding to slower HRr values (Brinkworth, Noakes, Buckley, Clifton, 2006; Carroll, Marshall, Ingle, Borkoles, 2012; Georgiopoulou, et al.; 2012). Body mass index (BMI), body fat, and waist circumference have been shown to be modifiable with cardiovascular (CV) exercise, and have strong correlations with HRr among healthy and sedentary individuals (Brinkworth et al., 2006; Carroll et al., 2012; Esco, Williford, Olson, 2011; Kim et al., 2010; Matsuo et al., 2014; Thomson et al., 2010). Essentially, HRr has been shown to improve in a variety of populations (including diseased and overweight/obese) with exercise participation, but the exact physiological mechanisms of influence is not well understood. Adding further confusion is the emotional or mood influence on the parasympathetic and sympathetic nervous systems (Weir, 2011). The Profile of Mood States (POMS) questionnaire was designed as a reliable and validated measure of emotional state that assesses anger, vigor, fatigue, tension, depression, and confusion as well as total mood disturbance (Bourgeois, LeUnes, Meyers, 2010; McNair, 1971). Schmikli, De Vries, Backx (2010), found that POMS was sensitive to changes in workload and recovery and correlated well with rate of perceived exertion. Using the POMS, recent literature has shown that HRr from submaximal exercise was not impacted by fitness levels or emotional state among individuals with at least average fitness (Bunn et al., 2017).

With the consistent demonstration that HRr may be modifiable with CV fitness training and changes in body composition, it's not clear to what extent the factors have influence, or what other factors may contribute to changes in HRr. As such, the primary purpose of this study was to evaluate differences in HRr between untrained and trained individuals after maximal and submaximal exercises while simultaneously assessing the role of physiological and emotional factors on HRr in both populations.

Material and methods

Participants

Prior to participation in the study, all participants provided a written informed consent as approved by the university Institutional Review Board. Eighteen untrained, overweight or obese males (n = 5) and females (n = 13) and 21 recreationally trained, normal weight males (n = 7) and females (n = 14) participated in this study. Inclusion criteria for the untrained group were: a BMI of or greater than 25, or a waist circumference of 102 cm or larger for men and 88 cm or larger for women, and self-report of a sedentary lifestyle. Inclusion criteria for the trained group were: a BMI ranging from 18.5 to 24.9 and self-report of exercise participation of at least 150 min/wk of moderate intensity exercise or 75 min/wk of vigorous intensity exercise. All subjects had to be between the ages of 18–55 years old, and considered low to moderate risk for CV disease without any signs or symptoms of CV disease (Riebe, Ehrman, Liguori, Magal, 2017) .

Procedures

Participants completed two testing sessions 48 hours apart. The first testing session consisted of assessing height, weight, resting hemodynamics, BMI, body composition, a psychological assessment, and a treadmill maximal

graded exercise test (GXT). Height was measured using a standard stadiometer. Weight and body composition was measured using bioelectrical impendence analysis (BIA) using the InBody 570 (Biospace, Cerritos, CA). Resting heart rate and blood pressure were measured manually using standard procedures after the participant had been seated for at least five minutes. Participants completed the psychological assessment using the online version of the POMS questionnaire (Mackenzie, 2001). Mood states of anger, confusion, depression, fatigue, tension, vigor, and total mood disturbance were used to determine the participant's psychological state prior to exercise. These moods have been shown to be stable in various scenarios (Bourgeois et al., 2010; Mackenzie, 2001; Pronk, Crouse, Rohack, 1995). Mood scores were totaled to determine the disturbance (–32–200) of the participant, with a high positive number indicating an angry or sad mood, and a high negative number indicating a happy or excited mood (Mackenzie, 2001; Weinberg, Gould, 2011).

For the maximal GXT, the Bruce protocol was used for the untrained participants, and a modified test was used for the trained participants, wherein they ran at a challenging pace and treadmill incline was increased 2% every three minutes, until volitional exhaustion. During the GXT, oxygen consumption (VO_2) and carbon dioxide production were measured using a metabolic analyzer (Parvomedics, Sandy, UT). HR was measured via a Polar Chest Strap (Lake Success, NY), and was monitored for five minutes post-exercise. After completion of the GXT, participants completed a 2-min cool-down walking at 1.12 $m \cdot s^{-1}$, and then sat in a chair for three minutes to obtain five full minutes of HRr.

The participants returned for the second testing session 48 hours after the initial session, and completed a 20-minute treadmill exercise at 55–70% HR reserve. HR was again measured using the Polar chest strap. After completion of the 20-minute exercise, participants walked at 1.12 $m \cdot s^{-1}$ for two minutes and then sat in a chair for an additional three minutes. HR was monitored for the duration of the exercise and post-exercise for 5 minutes.

Absolute HRr was calculated by subtracting HR measurement post-exercise heart rates from the peak HR obtained during bout. Relative HRr was calculated by dividing the absolute HRr by peak HR and multiplying by 100. Recovery HR measurement were taken 2- and 5-min after the GXT, and 1-, 2-, and 5-min after the submaximal bout.

Statistical analysis

Statistical analysis was done using SPSS (Chicago, IL), with an *a priori* alpha level set at 0.05. Tests for normality were run prior to the parametric assessments. Multivariate analysis of variance (MANOVA) was used to evaluate group differences in HRr, body composition, BMI, resting hemodynamics, VO_2max, and POMS scores. Multiple step-wise regression was used to assess which variables (e.g. resting HR, VO_2max, BMI, body composition, mood states) were related to HRr after the maximal GXT (2- and 5-min HRr) and submaximal exercise (1-, 2-, and 5-min HRr). Data are presented as mean ± standard deviation (SD). Effect size of group differences was calculated using Cohen's d and 95% confidence intervals. Interpretation of effect sizes was as follows: 0.2 was considered small, 0.5 was considered moderate, and 0.8 or larger was considered large (Kazis, Anderson, Meenan, 1989).

Results

Group differences

The MANOVA revealed a significant main effect between groups ($Lambda_{9,29}$ = 0.238, p < 0.001; Table 1). Specifically, the groups were statistically different in mass ($F_{1,37}$ = 21.55, p < 0.001), resting HR ($F_{1,37}$ = 15.527, p < 0.001), percent body fat ($F_{1,37}$ = 62.799, p < 0.001), and BMI ($F_{1,37}$ = 44.982, p < 0.001). Additionally, the POMS score for vigor was found to be significantly different between groups ($F_{1,37}$ = 6.754, p = 0.013). Of particular note, is that the untrained group can truly be considered obese as the mean BMI is considered obese and the mean percent body fat would be classified as poor to very poor regardless of age and gender (Riebe et al., 2017).

Significant group differences were found at the first testing session for relative VO_2max ($F_{1,37}$ = 47.671, p < 0.001), absolute HRr at 2-minutes post-exercise [$F_{1,37}$ = 12.125, p = 0.001, d = 1.12 (0.43, 1.78)], relative HRr at 2-minutes post-exercise [$F_{1,37}$ = 10.845, p = 0.002, d = 1.06 (0.37, 1.71)], absolute HRr at 5-minutes post-exercise [$F_{1,37}$ = 6.418, p = 0.016, d = 0.81 (0.14, 1.45)], and relative HRr at 5-minutes post-exercise [$F_{1,37}$ = 5.888, p = 0.020, d = 0.77 (0.10, 1.41)]. Absolute and relative HRr after the maximal GXT (Figure 1) showed a similar rate of recovery during the three minutes between short- and long-term recoveries. Effect sizes for these specific differences are all considered large. It is noteworthy that the untrained group's mean VO_2max is classified as poor to very poor regardless of age and gender to indicate that this truly was an untrained group (Riebe et al., 2017). Additionally, the untrained group had significantly slower HRr than the trained group at both time points, indicating a higher risk of all-cause mortality.

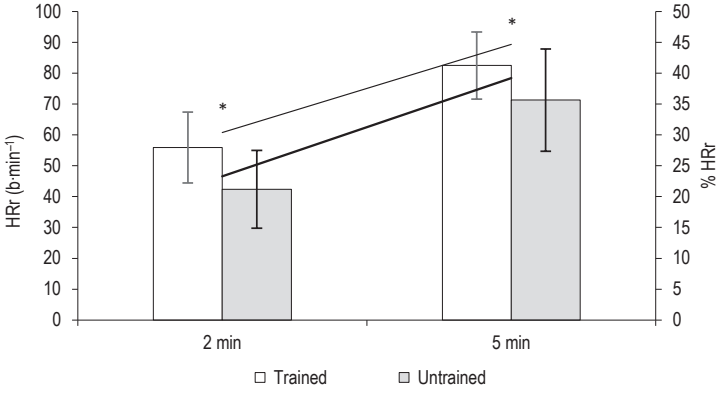
Table 1. Participant demographics and baseline study metrics

Metric	Trained	Untrained	Effect Size (95% CI)
Age (years)	31.5 ±14.7	30.1 ±12.4	0.10 (–0.53, 0.73)
Height (cm)	172.1 ±10.8	170.0 ±11.6	0.19 (–0.45, 0.82)
Mass (kg)*	70.6 ±11.6	103.9 ±29.5	–1.53 (–2.21, –0.79)
BMI*	23.7 ±2.6	36.0 ±8.0	–2.14 (–2.88, –1.31)
Body Fat Percent (%)*	22.0 ±7.1	41.3 ±8.1	–2.55 (–3.33, –1.66)
Heart Rate: Rest*	67.9 ±13.2	83.7 ±11.6	–1.27 (–1.93, –0.55)
Systolic BP (mmHg)	120.1 ±12.9	126.4 ±14.7	–0.46 (–1.09, –0.19)
Diastolic BP (mmHg)	76.5 ±8.6	78.9 ±9.4	–0.38 (–1.00, 0.27)
VO_2max ($l \cdot min^{-1}$)	3.10 ±0.80	2.65 ±0.90	0.53 (–0.12, 1.16)
VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$)*	42.3 ±6.8	26.1 ±8.8	2.08 (1.26, 2.81)
Max heart rate ($b \cdot min^{-1}$)	185.3 ±14.4	180.7 ±13.6	0.33 (–0.31, 0.95)
POMS Score: Vigor, session 1*	–16.9 ±5.8	–12.3 ±5.0	0.83 (0.15, 1.46)
Mean HR, session 2 ($b \cdot min^{-1}$)	134.8 ±10.5	136.0 ±6.3	–0.14 (–0.76, 0.50)
Peak HR, session 2 ($b \cdot min^{-1}$)	157.3 ±10.9	154.5 ±12.4	0.24 (–0.40, 0.87)
POMS Score: Vigor, session 2*	–16.3 ±6.8	–11.0 ±5.8	0.83 (0.16, 1.47)

* Denotes significant group differences (p < 0.05).

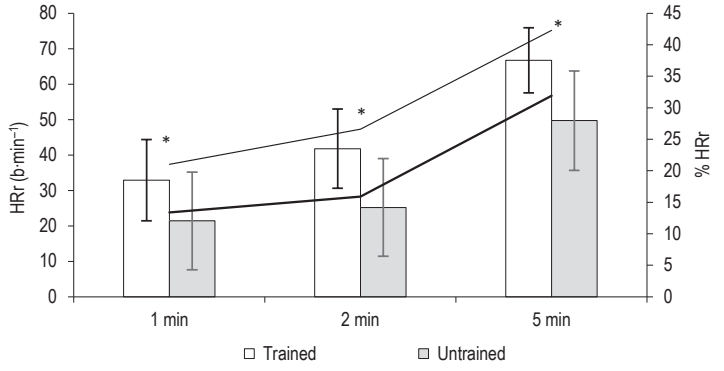
For the second testing session (Figure 2), significant group differences were found for absolute HRr at 1-minute post-exercise [$F_{1,37}$ = 8.017, p = 0.007, d = 0.91 (0.23, 1.55)], relative HRr at 1-minute post-exercise [$F_{1,37}$ = 9.92, p = 0.003, d = 1.03 (0.34, 1.68)], absolute HRr at 2-minutes post-exercise [$F_{1,37}$ = 17.035, p < 0.001, d = 1.33 (0.61,

2.00)], relative HRr at 2-minutes post-exercise [$F_{1,37}$ = 21.049, p < 0.001, d = 1.48 (0.74, 2.16)], absolute HRr at 5-minutes post-exercise [$F_{1,37}$ = 20.604, p < 0.001, d = 1.46 (0.72, 2.13)], and relative HRr at 5-minutes post-exercise [$F_{1,37}$ = 26.210, p < 0.001, d = 1.65 (0.89, 2.34)], and vigor as measured by the POMS ($F_{1,37}$ = 6.908, p = 0.012). The effect sizes for the group differences in HRr are considered large.



* Denotes a statistically significant difference between groups (p < 0.05).

Figure 1. Absolute HRr (primary y-axis) and relative HRr (secondary y-axis) 2-min and 5-min after the participants completed a maximal GXT



* Denotes a statistically significant difference between groups (p < 0.05).

Figure 2. Absolute HRr (primary y-axis) and relative HRr (secondary y-axis) 1-min, 2-min, and 5-min after the participants completed a 20-minute moderate-intensity treadmill exercise

Regression analyses

The regression analyses revealed significant predictors of HRr for both groups (Table 2). Resting HR was a significant primary predictor for short-term HRr for the trained group. Peak HR, primarily for short-term recovery, and mean HR, only after submaximal recovery, also showed to be significant predictors for this group. Interestingly, none of the variables were statistically significant for the 1-min HRr after the submaximal exercise. For the untrained group, resting HR was also the primary variable for predicting HRr, but other variables such as peak HR (mostly in long-term recovery), VO_2max, mean HR, age, and body fat (all significant with recovery after submaximal exercise) were also significant predictors. HRr was not significantly related to POMS for either group at any time point. Of particular note is that R-values tended to be higher in the untrained group than the trained group, indicating greater predictive value and influence of the physiological variables on HRr.

Table 2. Predictive variables for heart rate recovery after maximal and submaximal exercise

	Resting HR	Peak HR	VO_2max	Mean HR	Age	% BF	Trained	Untrained
				Maximal Exercise				
Abs 2-min	* †						R = 0.551, p = 0.010	R = 0.799, p < 0.001
Rel 2-min	* †						R = 0.609, p = 0.003	R = 0.764, p < 0.001
Abs 5-min	†	†					N/A	R = 0.809, p < 0.001
Rel 5-min	†	*					R = 0.447, p = 0.042	R = 0.661, p = .003
				Submaximal Exercise				
Abs 1-min	†		†	†			N/A	R = 0.967, p < 0.001
Rel 1-min	†		†	†			N/A	R = 0.977, p < 0.001
Abs 2-min	* †		†	†			R = 0.583, p = 0.006	R = 0.959, p < 0.001
Rel 2-min	*	* †		* †		†	R = 0.818, p < 0.001	R = 0.927, p < 0.001
Abs 5-min	†	* †			†		R = 0.591, p = 0.005	R = 0.903, p < 0.001
Rel 5-min	†				†		N/A	R= 0.811, p < 0.001

* Indicates significant predictors for the trained group, and † indicates significant predictors for the untrained group.

Discussion

The trained group had a significantly faster absolute and relative HRr and a higher relative VO_2max than the untrained group. This was demonstrated both in the maximal testing session, as well as the submaximal exercise session, and these findings are consistent previous research (Borresen, Lambert, 2008; Brinkworth et al., 2006; Brown, Brown, 2007; Bunn et al., 2017; Carroll et al., 2012; Dixon, Kamath, McCartney, Fallen, 1992; Lamberts, Swart, Capostagno, Noakes, Lambert, 2010; Sugawara, Murakami, Maeda, Kuno, Matsuda, 2001). Interestingly, the graphical representations of the absolute and relative HRr show that the gap in recovery between the two groups tends to be the same regardless of the time point (Figures 1 and 2). This indicates that the two groups have the same slope and pattern of recovery. The trained group recovered faster within a shorter time frame after exercise than the untrained group, but the untrained group was able to keep up with this “recovery pace” during the longer recovery period. These results agree with data previously published by Pierpont et al. (2013).

Results also showed a difference in resting HR and no difference in peak HR between groups. Resting HR was expected to be lowered in trained individuals, indicating a greater parasympathetic tone and CV efficiency.

This further demonstrates the significant improvements that can be made to resting HR and HRr with regular CV training (Georgiopoulou et al., 2012; Matsuo et al., 2014; Thomson et al., 2010). No difference between groups for peak HR indicates that both groups worked at approximately the same intensity during both exercise sessions, which is important to address with recovery. The POMS score for vigor is the last group difference of note. The higher score for the trained group indicated higher robustness, stamina, and a more positive outlook. In theory, this outlook could indirectly influence autonomic control on the heart, but the multiple regression analysis from the present study does not support this concept. This suggests that, while different between groups, mental state had no effect on HRr. This result does not agree with research among competitive athletic teams that emphasizes mental health status being a significant predictor of performance and recovery (Crust, Clough, 2005; Kuan, Roy, 2007).

Detailed analysis of the trained group revealed that resting HR was the most common predictor of HRr shortly after (2-min) exercise. Resting HR is primarily controlled by intrinsic factors and parasympathetic influence (Daanen, Lamberts, Kallen, Jin, Van Meeteren, 2012), and trained individuals tend to have a stronger vagal tone than untrained. Thus the correlations between short-term HRr and resting HR for this population shows dominance of the parasympathetic nervous system very quickly post-exercise (Coote, 2010). Long-term HRr (5-min) was linked with maximal HR, providing a greater indication that intensity and duration of the exercise is more influential on this longer portion of recovery (Hautala et al., 2001; Murrell et al., 2007). The untrained group showed similar trends in that resting HR and maximal HR were strong predictors of both short- and long-term HRr respectively. Other factors like VO_2max, mean HR, age, and body fat showed to be predictors of HRr for this group after submaximal exercise. There have been mixed results in the literature with these factors. A previous study showed no correlation between VO_2max and HRr in recreationally trained individuals (Bunn et al., 2017), but another study showed that VO_2max and physical activity participation were correlated with HRr in trained persons, with the stronger predictor of HRr being physical activity participation (Lee, Mendoza, 2012). Collectively these data suggest that perhaps after one reaches at least a threshold of "average" VO_2max, then level of fitness is no longer a significant predictor for HRr. More research on this hypothesis needs done to prove the merit of this concept.

As a direct comparison between those persons of higher body mass and lower body mass, this study makes some assumptions about the level of physical fitness in each group. This could be identified as a limitation in study design, as the groups may not be truly different in their health status as determined by mass and BMI alone; though the statistical difference between groups and large effect sizes help to mitigate those assumptions. Another limitation may be that assessment of psychological variables was completed only prior to activity participation. This single assessment before each session does not assess any potential changes in participant mental state after completing exercise, and may contribute to the absence of vigor as a contributing factor to HRr.

Using the data from this study, further assessment of a potential link between HRr and psychological state of the participant is useful, as it still may be a valuable tool when evaluating a patient for total body wellness and fitness and the "before and after" effect of exercise on mental health and physiologic markers of fitness. Additionally, it may be beneficial to further explore if a physical activity participation and/or CV fitness level threshold exists in relation to healthy HRr. Diseased and disabled populations could use this information to reduce their risk for all-cause mortality.

Conclusion

This study further bolsters the growing body of literature that uses HRr as a predictive tool for overall health, demonstrating that a group of trained participants has a quicker HRr after maximal and submaximal exercise relative to an untrained population. It also reinforces the physiologic theory that HRr is modifiable with regular CV exercise. Yet, it poses additional questions about a threshold in activity participation and fitness for optimal HRr, as well as questions regarding mood status and its relationship to fitness and health, and further exploration of those theories is still needed.

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CARDIAC REHABILITATION IN HEART FAILURE. PART II. DOES HIGHER INTENSITY MEANS BETTER OUTCOME?

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Abstract Heart failure (HF) due to its universality has become a huge challenge for modern medicine. Second part of the twentieth century brought significant changes in the rehabilitation, diagnostic and pharmacological procedures. There are no definitive guidelines for Cardiac Rehabilitation (CR) in HF. Based on previous studies, the article tried to describe and illustrate the mechanism of effective CR and its intensity in HF patients, which could be helpful in CR protocol development.

Cardiac Rehabilitation has confirmed efficacy in increased physical level of participation in inter alia, home/work/recreational activities, improved psychosocial well-being, functional independence, prevention of disability, long-term adherence to maintaining physically active lifestyle, improved cardiopulmonary fitness, strength, muscle endurance, and flexibility, reduced cardiovascular events risk and risk of mortality.

Before and after CR conduction, baseline and final aerobic capacity should be examined with an ergospirometry test to evaluate CR protocol intensity and check its effectiveness, respectively. Frequency of training-bouts in CR protocol in HF patients were from 3 to 7 days per week, intensity ranged from 40 to 80% VO_2max or 9 to 14 on rating of the perceived exertion (RPE) scale or 6 to 20 on the Borg scale. Duration of single bout-exercise ranged from 20 to 60 minutes.

Key words cardiac rehabilitation, physical exercise, heart failure, aerobic training, resistance training

Introduction

Cardiac rehabilitation and heart failure

Heart failure (HF) due to its universality has become a huge challenge for modern medicine. Second part of the twentieth century brought significant changes in the rehabilitation, diagnostic and pharmacological procedures. Cardiac Rehabilitation (CR) is the gold standard in care of patients with heart diseases (Blumenthal et al., 2016).

CR programs are based on the patient's clinical status, with three phases included most often. Phase 1 is an inpatient program which should be started soon after the acute cardiac event or intervention. The main goal is to mobilize elderly HF patients. Patients in phase 2 have three training bouts per week, for a total of 36 sessions over a period of 3–4 months. Training protocol includes simple home-based, self-supervised programs or with telephone electrocardiographic (ECG) monitoring. Phase 3 refers to non-ECG-monitored programs utilities, without medical supervision or fitness facilities included (Balady et al., 2011).

Comprehensive rehabilitation is designed to help the patient to return to full physical activity and to reduce cardiovascular events. Cardiac rehabilitation should be started as soon as possible after stabilization of the patient, even during he/she is in intensive care. Depending on the functional state of the patient, further stages of physical activity should increases which could facilitate a faster recovery (Smarż, 2008). However, it is worth paying attention to the contradictions list to take part in CR, which are presented in Table 1.

Methods of cardiopulmonary assessment in HF patients

To evaluate HF patients readiness to take the physical effort, at least one pre-test should be assessed. In case of aerobic capacity, there are few methods used in clinical examination.

One of the cost-free functional tests is the six-minute walking test (6MWT) (Lipkin, Scriven, Crake, Poole-Wilson, 1986). Result of this test is the number of meters walked in six minutes. The patient should be asked to walk as fast as he/or she is able to, reminding that they ought to maintain the same velocity during the whole test. Patients should be reminded about the duration of the test and ask to think about the walk velocity which he or she is able to maintain during this time. Patients should walk alone, if not, sufficient time interval between examination of the next patient have been maintained to exclude the competition factor. Some studies (Roomi et al., 1996) showed that creating competitive conditions can increase mean results of patients in this test up to 30%, comparing to group without such conditions. If necessary, physician can walk behind the patients for the whole test time. Practice time before actual test should be provided. Moreover, mean result for this test was reported to be 631 meters and was 84 meters greater in men compared to women, results were based on 51 healthy subjects aged 50–85 (Troosters, Gosselink, Decrame, 1999). Moreover, obtained result in the 6MWT could have a prognostic value (Rostagno et al., 2003).

Cardiopulmonary exercise stress testing (CPX) is a gold standard in the maximal aerobic capacity assessment. It provides several physiological parameters derived from cardiac system (through ECG) and ventilatory system, some are based on calculations based on parameters from both systems (i.e. O_2 pulse, which is a report between O_2 uptake and heart rate (VO_2/HR). Ventilatory system parameters are, i.a., maximal oxygen consumption (VO_2max), production of the carbon dioxide per unit of time (VCO), ventilatory exchange (VE), respiratory exchange ratio (RER). The rate of the maximal oxygen consumption (VO_2max) is traditionally expressed as milliliters per minute or as milliliters per kilogram per minute and is affected by age, gender, body weight, muscle mass, and conditioning

status. VO_2max adjusted to the lean body mass obtained During CPX test elevated the prognostic value of CPX test in the assessment of patients with chronic HF (Osman, Mehra, Lavie, Nunez, Milani, 2000; Weber, Janicki, 1985).

Decreased VO_2max was estimated as a significant predictor of the mortality, moreover increasing of the VE/VCO_2 slope is a good predictor as well (Francis et al., 2000).

The use of <19 ml O_2/kg of lean body mass/min could serve as a cut-off point which could serve in determination of the transplantation schedule, particularly in women and the obese (Osman et al., 2000). Corra, Mezzani, Bosimini, Giannuzzi (2004) have developed an algorithm for the risk stratification procedure with symptom-limited CPX in chronic HF patients. An algorithm is based on a multiparametric decoding scrutiny incorporating the stepwise implementation of the following parameters: Vo_2max, VE/VCO2 slope, and RER max (Corra et al., 2004).

Interestingly, exercise echocardiography testing combined with CPX testing could serve as a best method in the determination of effort intolerance in HF patients (Shimiaie et al., 2015).

Table 1. Absolute and relative contraindications for exercise training in HF patients (adapted from Adsett, Mullins, 2010)

Absolute contraindications
1. Progressive worsening of exercise tolerance or dyspnoea at rest or on exertion over previous 3–5 days
2. Significant ischaemia at low exercise intensities (<2 METS, or ~50 W)
3. Uncontrolled diabetes
4. Acute systemic illness or fever
5. Recent embolism
6. Thrombophlebitis
7. Active pericarditis or myocarditis
8. Severe aortic stenosis
9. Regurgitant valvular heart disease requiring surgery
10. Myocardial infarction within previous 3 weeks
11. New onset atrial fibrillation
12. Resting heart rate >120 bpm
Relative contraindications
1. ≥2 kg increase in body mass over previous 1–3 days
2. Concurrent continuous or intermittent dobutamine therapy
3. Decrease in systolic blood pressure with exercise
4. New York Heart Association Functional Class IV
5. Complex ventricular arrhythmia at rest or appearing with exertion
6. Supine resting heart rate ≥100 bpm
7. Pre-existing co-morbidities
8. Moderate aortic stenosis
9. BP > 180/110 mmHg (evaluated on a case by case basis)

Cardiac Rehabilitation protocol – aerobic training

Low or moderate exercise intensity is recommended for patients with HF. It improves maximal oxygen uptake, exercise tolerance and quality of life, and also reduces hospitalization and mortality (Benito, Nattel, 2009).

A randomized-controlled trial have shown that 2 months of the moderate exercise can improve VO_2max by 18% (Belardinelli, Georgiou, Cianci, Purcaro, 1999).

In 2004, a meta-analysis of 9 randomized controlled trials of ExTraMATCH involving 801 people with HF (395 people taking rehabilitation, 406 served as a control group) demonstrated a 35% decrease in mortality and a 30% decrease in re-hospitalization in people after 2 years of rehabilitation (Piepoli, Davos, Francis, Coats, 2004).

It is worth noting that exercise intolerance in HF patients contributes to the continuous deterioration of health: skeletal muscle weakness and walking disorders, among others (Keast et al., 2013). Nordic Walking could serve as an effective and above all a safe activity with positive effect mainly on the circulatory system and respiratory system. Recent studies show that the use of Nordic Walking as an intervention in HF patients has shown that after a 12-week workout the functionality has increased by 18%, estimating by a 6MWT. A significant group of people with heart disease may experience depressive symptoms. These symptoms can contribute to adverse complications. After the 12-week intervention the symptoms of depression measured by Hamilton Rating Scale for Depression have decreased noticeably (Keast et al., 2013).

Prospective randomized study evaluated the effect of exercise training on left ventricular function (LV) and haemodynamic response in patients with chronic HF (Hambrecht et al., 2000). The study involved 73 men aged 70 years with chronic heart failure (LV ejection fraction circa 0.27). Both groups underwent echocardiography and exercise tests at baseline and after 6 months. Patients were asked to engage in the activities that will increase their heart rate for 20 minutes each day for 6 months. In addition, they attend in at least 1 training bout lasting 60 minutes in each week. Exercise protocols included walking, strengthening exercises and ball games. Patients assigned to the control group continued their individualized cardiac medication and were supervised by physicians. Three key conclusions were drawn during the study. First, aerobic endurance training leads to increased LV stroke during rest and during exercise and to slight but significant decrease in diameter and end-diastolic volume. Moreover, long-term training exercises are associated with significant reductions of the TPR at rest. In addition, a significant correlation was estimated between vascular endothelial vascular improvement and TPR decrease during exercise. Third, changes in TPR were associated with changes in cardiac output and end-diastolic diameter (Hambrecht et al., 2000).

In randomized controlled trial from 2007, twenty-seven HF patients with standard pharmacological treatment (LV ejection fraction 29%, VO_2max 13 mL/kg/min) were randomized to either medium-intensive continuous training (70% HRmax) or aerobic interval training (95% of HRmax), 3 bouts of training for 12 weeks in total (Wisløff et al., 2007). There was a significant 46% VO_2max improvement in intervention group, compared to 14% in the moderate continuous training group and was associated with reverse LV remodeling. Moreover, only the intervention group noted the reductions in the LV end-diastolic and end-systolic volumes. In addition, LV ejection fraction and mitochondrial function in lateral vastus muscle increased improved and intervention group (Wisløff et al., 2007).

In the study from 2011 (Edelmann et al., 2011) 64 HF patients were incorporated into intervention (exercise) or control (usual care) groups. Training protocol intensity increased: two bouts of aerobic per week, 20–40 min with 50–60% of VO_2max were conducted in the first 4 weeks of protocol. In the fifth week, the intensity of aerobic training protocol increased to 70% VO_2max, resistance training was incorporated as well as. During the resistance training, subjects were doing 15 repetitions at one training bout 60 to 65% of their 1 repetition maximum. VO_2max and the score in the physical functioning questionnaire increased significantly in the intervention group compared to the control (Edelmann et al., 2011).

RCT with non-active control group on 2,331 patients with Left Ventricular Ejection Fraction (LVEF) <35% induced training protocol consisted of 36 training-bouts (3-months, home exercises 5 time/week for 40 minutes,

target HR was 60% HRR increased to 70% after patients adaptation to exercise). During follow-up a decrease in mortality (–4%, p = 0.7), cardiovascular mortality and hospitalization (–8%, p = 0.14), cardiovascular mortality and hospitalization for HF (–13%, p = 0.06) was observed, comparing to the control group (O'Connor et al., 2009). These results were reexamined after adjusting for confounding factors such: baseline exercise duration, LVEF, depression severity and a history of cardiovascular conditions. Analysis revealed that the rate of total mortality or hospitalization (–11%, P = 0.03), cardiovascular mortality or hospitalization (−9%, P = 0.09), and cardiovascular mortality or cardiovascular hospitalization (−15%, P = 0.03) decreased, thus suggesting that exercise training had beneficial effects in patients with HF (O'Connor et al., 2009).

Adsett et.al. (Keast et al., 2013) recommended an interval training with using different modalities of motor patterns, i.a., cycle ergometer, treadmill, rowing machines, step aerobics, calisthenics; swimming and Tai Chi, 3–5 time/week, 50–70% VO_2max or 60–80% HRR; RPE between 9 and 14 on the Borg 6–20 scale, 10–20 min and progress to longer sessions 30–40 min (Adsett, Mullins, 2010).

Table 2. Protocols of cardiac rehabilitation including resistance exercise

		Resistance training							
Author		Adsett et al., 2010	Piepoli et al., 2011			Piña et al., 2003	Selig et al., 2010		Ades et al., 2013
Main goal		–	pretraining	resistance training	strength training	–	NYHA class I–II	NYHA III–IV	-
Intensity	1 RM	60% 1 RM	<30% 1 RM	30–40% 1 RM	40–60% 1 RM	–	–	–	–
	Borg scale	9–13	–	–	–	–	6–20	6–20	-
	RPE	6–20	<12	12–13	<15	–	11–14	10–13	-
Repetitions		8–15	5–10	12–25	8–15	–	6–15	4–10	10–12
Sets		2-4	1–3 circuits/ session	1 circuit/ session	1 circuit/ session	–	1–3 4–8	1–2 3–4	1–2
Frequency		1–2 days/wk	2–3/wk	2–3/wk	2–3/wk	–	2–3days/wk	2–3days/wk	2–3 days/wk
Duration		20–30 min	–	–	–	–	Extra 5 min stretch	–	–
Additional recommendation proposed by author		Avoid isometric exercises	Avoid Valsalva or abdominal straining			Safety and efficacy of RT has not been established Elastic band Repetitive isolated muscle training	Circuit weight-training TheraBand exercises Body weight exercise Different exercises for major muscle group For NYHA I–II 5 min post-training stretching the major muscle group		Exercises engaging major muscle groups

Pina et.al. (Piña et al., 2003) showed that cardiac rehabilitation recommendation for HF patients are still not clear. Most safety options are aerobic exercises on treadmill and bicycle ergometry with frequency 3–5 d/wk and walking on non-training days, 70–80% VO_2max; 60–65% VO_2max, Borg scale RPE of 12–13. During single training bout, 10–15 min should be spent for proper warm-up with 20–30 minutes of the main part and lastly, period of cool-down should be also included (Piña et al., 2003). Meta-regression analysis from 2016 (Uddin et al., 2016) on predictors of exercise capacity following exercise-based rehabilitation in patients with coronary heart disease and heart failure included trials in which exercise frequency ranged from 3 to 4 days per week (mean: 3,6),

training bout duration ranged from 35 to 47 minutes (mean: 41 minutes), training protocol duration lasted from 22 to 31 months (mean: 27) and exercise intensity ranged from 50 to 85% of Hrmax and VO_2max (Uddin et al., 2016). Interestingly, low-intensity CR (40% VO_2max) for 8 wk, 3 days per week could be effective in some patients (Belardinelli, Georgiou, Scocco, Barstow, Purcaro, 1995).

Cardiac Rehabilitation protocol – resistance training

A CR typical exercise training session consists of three parts. First, 5 minutes of warm-up (stretching and light calisthenics, exercise training using light weights or exercise machines-biceps curls, triceps extensions, military presses, shoulder shrugs, bent-knee push-ups, bent-knee "crunches," and quarter squats, addressed to the major muscle groups). This part increase patients' ability to perform daily living and work (lifting and carrying). Second part includes 20 minutes of aerobic exercise training and third part 5–15 minutes of cool-down (Balady et al., 2011).

Additional strength training included into training protocol could lead to muscular strength and endurance in the exercise-trained muscle improvement.

Adsett et.al. recommended to avoid isometric exercises and used light weights only (Adsett, Mullins, 2010). Initial training bouts intensity should incorporate lifting weights of approximately 40% of one-repetition maximum (1 RM) then while patients exercise adaptations could increase to 60% 1 RM. Training protocol should incorporate 1–2 training bouts each week, with duration range of 20–30 min, and 2–4 sets for each exercise in a range of 8–15 repetitions (Adsett, Mullins, 2010).

Table 3. Protocols of cardiac rehabilitation including aerobic exercise

		Aerobic training						
Authors		Adsett et al., 2010	Piepoli et al., 2011	Piña et al., 2003	Piña et al., 2003	Selig et al.2010		Ades et al., 2013
Type		steady/intermittent/interval; cycle ergometer, treadmill, rowing machines, step aerobics, calisthenics, swimming and Tai Chi	aerobic: continuous and interval	Aerobic, resistive or both	Treadmill, bicycle ergometry	Interval training: start 1 : 1, progress to 2 : 1 exercise/rest ratio		–
Frequency		3–5 days/wk	3–5 days/wk	3–5days/wk	3–5 days/wk	4–7 days/wk		4 days/wk
Patients classification on the baseline		–	–	–	–	NYHA class I–II	NYHA class III–IV	3–7 MET–h/wk
Intensity	VO_2 max	50–70%	40–50%, to 70–80%	60–80%	70–80%	40–70%, to 80%	40–60%	–
	Heart Rate Reserve	60–80%		60–70%		40–75%	40–65%	55–80%
	RPE	9–14	<15	–	–	11–14	≤13	–
	Borg Scale	6–20	–	13–14	12–13	6–20	–	12–14
Duration		Start 10–20 min, progress to 30–40 min	Start 5–10 min, progress to 20–60 min	–	Warm-up: 10–15 min, Aerobic: 20–30 min, Cool-Down	–	10–15 min, to 45–60 min	>30 min/ session
Additional recommendation proposed by Authors		Patients with higher risk	Medical history and patient examination	Individual protocol	Assessment of functional capacity	Individualized approach		Pretraining exercise testing

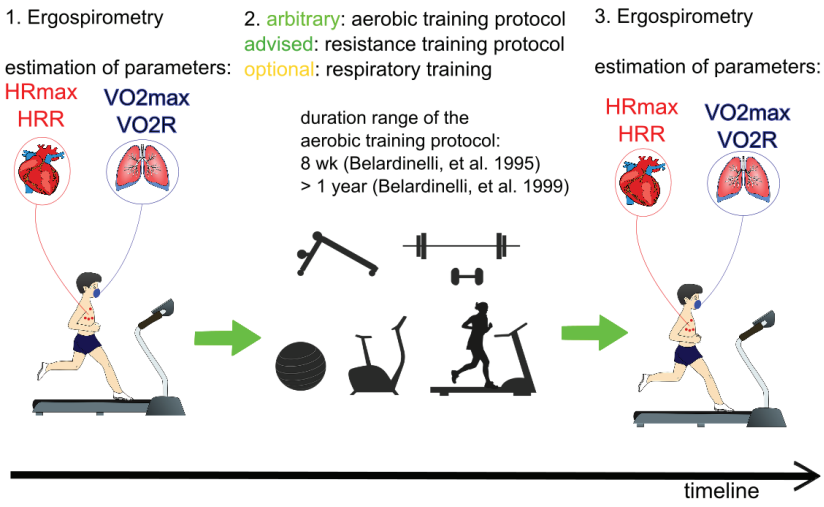

Figure 1. The timeline of the CR

Figure 1 shows the timeline of the CR. Optimal duration of whole protocol is very crucial: as other noted (Adsett, Mullins, 2010) training cessation causes physiological functioning reverse, therefore optimal protocol duration should be established.

Discussion

Taking part in CR is not free from contradictions (Giannuzzi et al., 2001), nevertheless could effectively improve patient's health in many dimensions. Anderson et.al. in meta-analysis of 63 studies draw conclusions that CR induction reduces the cardiovascular mortality, hospital stay and improves a quality of life (Anderson et al., 2016). However, Piña et.al. (2003) showed that cardiac rehabilitation recommendations for HF patients are still not clear. The same Authors claim that safety and efficacy of resistance training has not been established, however exercise training using small free weights (1, 2, or 5 lb), elastic bands, or repetitive isolated muscle training was proposed by Authors (Piña et al., 2003).

In general, aerobic exercise–training-bout in CR in above described researches lasted 20 minutes or longer (to maximum 60 min) and were performed at 40% (Belardinelli et al., 1995) to 80% Vo_2max, 40% to 80% of the HRmax, frequency 3–7 days/wk (Adsett, Mullins, 2010; Piña et al., 2003; Piepoli, et al., 2011; Selig et al., 2010; Ades et al., 2013). Noteworthy, it is crucial to examine the aerobic capacity before CR initiation, while some patients require CR protocol with lower intensity (Balady et al., 2011). Results of study based on 12 weeks training of CR and CR with *stress management training* (SMT), show significant improvements in coronary heart disease biomarkers and lower event rates of the cardiovascular diseases (Blumenthal et al., 2016). Lower rates of clinical events was noted in a group with mixed CR and SMT. Result of this study shows a positive effect of CR on patients' health but also underlies the importance of the comprehensive cooperation with other individuals from medical team such as psychotherapist (Blumenthal et al., 2016).

There are plenty of possible mechanism on level of systems, organs tissue and cells, by which CR can improve functioning of HF patients. CR, among other mechanisms, increases rest myocardial blood flow (Legallois et al., 2016), improves mean ratio of early to late mitral inflow velocities (Alves et al., 2012) decreases sympathetic tone while increasing parasympathetic tone of autonomic nervous system (Coats et al., 1992), decreases level of, inter alia, brain natriuretic peptide (Legallois et al., 2016), atrial natriuretic peptide and vasopressin, aldosterone (Braith, Welsch, Feigenbaum, Kluess, Pepine, 1999). There are also evidences that CR induction in patient with HF can improve cognitive functioning (Gunstad et al., 2005). That show us that it is still need for studies which examine the effectiveness of regarding a role and influence of CR on cognitive function (Gunstad et al., 2005).

In summary, CR should be based on comprehensive, interprofessional, individual approach to patient's needs, baseline patient assessment (VO_2max and/or maximal strength test which is crucial in establishing training protocol intensity); nutritional counseling and cardiovascular risk factor management; psychosocial interventions; and physical activity and exercise training counseling. Before, during and after CR in HF patients HR, blood pressure, clinical signs/symptoms, ST-segment changes, hemodynamics, perceived exertion, exercise capacity should be controlled. Moreover, as Authors of review describe (Piña et al., 2003), respiratory training seems to be very promising tool in CR especially in those patients with additionally respiratory system issues. Indeed, as results of meta-analysis shows (Montemezzo, Fregonezi, Pereira, Britto, Reid, 2014), inspiratory muscle training elicits greater improvement in patients with inspiratory muscle weakness.

There are many studies confirming the effectiveness of CR. Based on previous studies, we tried to describe and illustrate the mechanism of effective CR and its intensity in HF patients, which could be helpful in CR protocol development. Most importantly, further studies should aim to develop definitive and unified guidelines for CR in HF.

Conclusions

Cardiac Rehabilitation has confirmed efficacy in increased physical level of participation in home/work/recreational activities, improved psychosocial well-being, functional independence, prevention of disability, long-term adherence to maintaining physically active lifestyle, improved cardiopulmonary fitness, strength, muscle endurance, and flexibility, reduced cardiovascular events risk and risk of mortality. Interestingly, individual protocols of the above reviewed CR trials varied in terms of intensity and type of physical exercise (aerobic vs anaerobic) used, what in turn implies a question about the most effective CR protocol.

If the patient is free from contradictions to CR, then the first step of effective CR is to examine patients subjective ability to undertake aerobic exercise, which could be done by ergospirometry test most favourably, which is a gold-standard in aerobic capacity assessment. Moreover, maximal strength and spirometry tests could be additionally assessed. Then, based on the results of above mentioned tests, patient ability and/or the need to take part in the aerobic training, resistance training and/or respiratory training could be assessed as well as the intensity of the training protocol could be established.

Frequency of training-bouts in CR protocol in HF patients were from 3 to 7 days per week with 3 to 5 days per week being most common. Intensity ranged from 40 to 80% VO_2max and it is recommended to start at a lower range of intensity and progress to the higher one. Progression to 80% VO_2max should be done in hospitals. Interestingly, low intensity (40% VO_2max) for 8 wk protocol can be effective in some patients. Intensity presented as rating of perceived exertion (RPE) with a range of 9 to 14 on a Borg scale of 6 to 20 being acceptable. Duration of single

bout of exercise is advised to be 5 to 10 minutes and progressing up to 20 to 60 minutes per session with proper warm-up and cool-down periods included.

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TEST-RETEST RELIABILITY AND VALIDITY OF THREE DIFFERENT AGILITY TESTS FOR VARIOUS TEAM SPORTS IN YOUNG MALE ATHLETES

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Abstract The purpose of this study is to examine the reproducibility of three different agility tests in basketball, soccer and water polo team sports.

To determine the reliability 44 young male athletes (Basketball age 16.5 ±0.6, height 177.9 ±7.7 weight 70.0 ±7.1; Soccer age 16.3 ±0.5, height 169.2 ±5.0, weight 71.2 ±7.9; Water Polo age 17.1 ±0.7, height 181.3 ±6.7, weight 76.7 ±7.2) performed 3 different agility tests (Zig-Zag, Illinois and AS) on two occasions 1 wk. apart for test-retest. Sprint time scores were analyzed for each test. To determine the reliability Paired Sample T-test and Pearson Correlation Statistics were computed. Scores of teams were compared with ANOVA statistics to determine the difference.

Test results showed that there was no significant difference between the two occasions for all agility test on subjects and teams ($p > 0.01$). There was higher correlation between test-retest values of subjects ($r = 0.90–0.97$). Three different agility tests were found valid in determining agility with significant moderate level correlation. ($r = 0.36–0.44$; $p < 0.01$). Differences among sport branches were found significant for agility scores ($p < 0.05$).

All three agility tests are reliable and valid for team sport athletes. Soccer players had better scores than other branches in soccer specific test (AS). This study showed that sport specific agility tests are more useful than general agility tests.

Key words agility, team sports, soccer, water polo, basketball

Introduction

The purpose of this study is to examine the reproducibility of three different agility tests in basketball, soccer and water polo team sports. The agility is one of the most significant motor skill, especially for team sports. Different agility test shows different results. Because of that, to find suitable sport-specific agility tests are important for coaches, scouts, managers and physical educators to reach best and correct result. So, the hypothesis of this research was to clarify the usefulness of sport-specific agility tests for sports branches.

Team sport performance, which depends on the technical skills and physical fitness of the players, is known to significantly influence match performance. The simultaneous use of both technical skills and fitness in soccer training would produce extremely effective performance (Little, Williams, 2007). Agility is the ability to maintain and control correct body positions while quickly changing direction through a series of movements (Twist, Benicky, 1995). This ability is a determinant of sport performance in field and court sports, evidenced by time-motion analysis, validation of testing batteries for elite and non-elite performers, and coaching analyses for various team sports (Sheppard, Young, Doyle, Sheppard, Newton, 2006).

Agility in team sports can be defined as basic movements requiring the player to perform sudden changes in body direction in combination with rapid movement of the limbs (Ellis et al., 2000). Another explanation for agility is often recognized as the ability to quickly change directions and to start and to stop quickly (Little, Williams, 2005).

To examine agility of players accurately, it is argued that agility test must cater for different diminutions of agility skill such as reactive aspect of performance through the addition of a visual-perceptual test component (Farrow, Young, Bruce, 2005). Various agility tests have been developed to test players' ability of change of direction in use different team sports (Angeli, Nyland, 2006).

The outcome of an agility test can discriminate elite soccer players from the general population better than any other field tests, such as strength, power, or flexibility (Reilly, Bangsbo, Franks, 2000; Reilly, Williams, Nevill, Franks, 2000). Reilly and Williams (2003) have also identified the Illinois agility test (IAT) as one of best tests to measure of soccer's agility. The classical T-drill agility test, developed by Semenick (1990) can be used in different sports. However, a few studies have evaluated sport-specific test such as agility, including sprints, changes of direction and striking at the goal (Kutlu, Yapıcı, Yoncalık, Çelik, 2012). It is seen that the studies carried out when the researches on the subject are examined are not enough in quantity (Little, Williams, 2005).

Kutlu et al. (2012) have developed and evaluated a novel test of agility and striking skill for soccer that involves sprint running, direction changing, and kicking stationary balls to the goal with accurate decision making.

It's a curiosity, how different agility tests for different team sports show level of validity and reliability. The purpose of this study was to examine the reproducibility and validity of three different agility tests in basketball, soccer and water polo team sports.

Material and methods

44 young male athletes (n = 44, Basketball n = 23; Soccer n = 11, Water Polo n = 10) performed 3 different agility tests (Zig-Zag; Bloomfield et al., 1994; Illinois; Roozen, 2004, and The New Agility and Skill Tests; Kutlu et al., 2012). Physical characteristics of team sports players were shown in Table 1.

Table 1. Physical and physiological characteristics of young team sports players

Groups	N	Age	Sports age	Height	Weight	% Fat	BMI
Basketball	23	16.5 ±0.7	4.0 ±2.0	178.0 ±8.0	70.1 ±8.0	13	22.1 ±5.0
Water Polo	10	17.1 ±0.7	4.5 ±3.0	181.0 ±7.0	76.7 ±7.0	14	23.5 ±6.0
Soccer	11	16.4 ±0.5	4.0 ±2.0	180.0 ±7.0	71.2 ±8.0	12	22.0 ±5.0
All Players	44	16.6 ±0.6	4.2 ±2.0	18.00 ±7.0	72.6 ±8.0	13	22.5 ±5.0

*$p < 0.05$.

Three different agility tests are Zig-Zag (Bloomfield et al., 1994), Illinois (Roozen, 2004) and The New Agility and Skill Tests (Kutlu et al., 2012) were used to determine the reliability for three different sport athletes (soccer, water polo, basketball) on two occasions a week apart for test-retest. The best sprint time scores were recorded and were analyzed for each test. To determine reliability of tests Paired Sample T-test and Pearson Correlation Statistics were computed. Scores of teams were compared with ANOVA statistics to determine differences among team's validity. All players became familiar with the testing procedures utilized in the current study before the official test was applied. The study protocol and methods were approved by university institutional ethics committee and all subjects gave written informed consent prior to participation. Statistical analysis SPSS 21 software package was used for statistical analyzes ($p < 0.05$ and $p < 0.01$ were set for confidence level and in statistical calculations).

Results

Physical and physiological characteristics of young team sports players are determined as descriptive values in Table 1.

Table 2. Different agility scores of young team sports athletes

Agility tests	N	Basketball	Water polo	Soccer	All players
Zig-Zag (sec.)	44	6.54 ±0.34*	6.55 ±0.13	6.70 ±0.41	6.58 ±0.33
Illinois (sec.)	44	16.77 ±0.89	14.32 ±0.54*	17.25 ±0.86	16.33 ±1.38
Agility and Skill (sec.)	44	15.45 ±0.99	14.26 ±0.88	14.18 ±1.38*	14.86 ±1.22

* Significant differences between groups.

Test results showed that there was no significant difference between the two occasions for all agility test on subjects and teams ($p > 0.01$). There were high significant correlations found between test-retest values of subjects ($r = 0.90–0.97$). Agility scores of all groups were shown in Table 2.

Table 3. Results for Two Occasions of 3 Different Agility Tests and Pearson Correlations Reliability

Agility Tests (seconds)	Basketball	Water polo	Soccer
Zig-Zag (Pre-Test)	6.490	6.510	6.660
Zig-Zag (Post-Test)	6.540	6.580	6.740
Correlation	0.980**	0.900*	0.840**
Illinois (Pre-Test)	16.700	14.220	17.260
Illinois (Post-Test)	16.780	14.420	17.210
Correlation	0.944**	0.860**	0.914**
Agility and Skill (Pre-Test)	15.340	14.190	14.150
Agility and Skill (Post-Test)	15.470	14.330	14.210
Correlation	0.910**	0.891**	0.980**

* Correlation is significant at the 0,05 level (2-tailed).
** Correlation is significant at the 0,01 level (2-tailed).

Test results showed that there was no significant difference between the two occasions for all agility test on subjects and teams ($p < 0.01–p < 0.001$). There were high significant correlations found between Pre-test and

Post-test values of Zig-Zag test (r = 0.84–0.98). There were high significant correlations found between Pre-test and Post-test values of Illinois test (r = 0.86–0.94). Also, there were very high significant correlations found between Pre-test and Post-test values of Agility and Skill test (r = 0.89–0.98; p < 0.01). Agility scores of all groups were shown in Table 3.

Table 4. Pearson correlations of different agility tests for validity

Agility Tests	N	Zig-Zag	Illinois	Agility and skill
Zig-Zag	44	1.00	0.44**	0.36*
Illinois	44	0.44	1.00	0.40**
Agility and skill	44	0.36*	0.40**	1.00

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Three different agility tests were found valid in determining agility with significant light to moderate level correlation (r = 0.36–0.44; p < 0.01, Table 4). Differences among sport branches were found significant for agility scores (p < 0.05, Table 4). According to the Anova analysis, there were found significant differences among the test results of the three groups (p < 0.05). It has shown in Table 4.

Discussion

Agility and Skill Test, Zig-Zag test and Illinois agility tests were used to ensure the reliability of tests for team sports of soccer, basketball and water polo. All three agility tests were found reliable and valid for different team sports athletes (p < 0.05).

The within-subject variations in all 3 agility tests are acceptable similarly with some other studies (Pauole, Madole, Garhammer, Lacourse, Rozenek, 2000; Sporis, Jukic, Milanovic, Vucetic, 2010). The correlation values for the three different agility test obtained in this study are the highest. When comparing the results of our study with the results from previous studies in which the similar methods were used, we can conclude that young soccer players are nearly 1 second faster than other group of athletes especially in the test of soccer specific Agility and Skill test (p < 0.05) (Kutlu et al. 2012; Sporis et al., 2010). However, basketball players had better score on Zig-Zag test than others and water polo players had better score on Illinois test than others (p < 0.05) (Table 2).

Different team sports athletes had significantly different agility test scores in our study. Even soccer players had better scores than other branches in soccer specific test (AS) other team sports athletes could have better scores on other agility tests (Sporis et al., 2010). This study showed that sport specific agility tests should be chosen carefully for testing the athletes. So, they could be more suitable for different kind of team sports.

High-speed actions are known to impact soccer performance and can be categorized into actions requiring maximal speed, acceleration, or agility. Contradictory findings have been reported to the extent of the relationship between the different speed components (Little, Williams, 2005).

Based on the low coefficients of determination, it was concluded that acceleration, maximum speed, and agility are specific qualities and relatively unrelated to one another. The findings suggest that specific testing and training procedures for each speed component should be used when working with elite players.

Like mentioned above the study and in a specially designed research which is similar to our work; the famous footballer Cristiano Ronaldo has been subjected to different tests in a laboratory environment with high technological equipment ("Castrol Edge Presents Ronaldo Tested to the Limit", 2011). In terms of speed and agility, Ronaldo was tested and compared with a Spanish champion sprinter. As a result of the tests, in the agility test of Zig-Zag, Ronaldo was more successful than the sprinter athlete, however, failed to pass the athlete in the 25-meter sprint test. From these findings, it can be easily understood that the Zig-Zag agility test was more effective and suitable to determine the soccer specific performance for soccer players. In our study, there is a linear positive relationship, even if not at a high level, between the tests for all three sport branches (Table 3). This is an indication of the validity of the agility tests used in the study for different team sports. However, statistically significant differences in the performance of the agility tests were found (Table 4) ($p < 0.05$), indicating that some sports branches were more useful in some agility tests; (in such as, soccer players were successful in football-specific test than others) significantly outperform others in other agility tests, making the effectiveness and selectivity of tests relatively valid and thus questionable. (Little, Williams, 2005).

Conclusion

Thus, it is possible to arrive from the results that different speeds, quickness and agility tests have their specific characteristics and are relatively unrelated to each other. Therefore, in terms of speed, agility and short skills, the selection of the appropriate test is like problem and to find best the whose concerned, required some research endeavors in determining the suitable tests for coaches.

Consequently, the agility and skill of athletes are very important in talent identification, and to determine the performance development. Different sport branches could need sport specific agility skills. So, this type of sport specific research studies and practical results make sense and are beneficial for team sport coaches, sports managers and scouts. When the results of this study are evaluated, it may be possible to achieve better and significant performance results by using skill-based agility tests.

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THE CONDITIONS OF PRACTICING ASSOCIATION FOOTBALL BY WOMEN

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Abstract The aim of the work was to learn about the conditions of practicing football by women and to determine positive effects and negative stereotypes accompanying this discipline, the basis being the opinions of female players, as well as student self-government representatives. The study was conducted among 100 Polish female footballers from Exstraliga, 1st League and 2nd League, along with 31 members of student self-governments, representing all physical education universities in Poland. The diagnostic survey method was employed and the techniques of questionnaire, interview and participatory observation were used. For the statistical inference frequency of characteristics, the chi-square test of independence and multiple correspondence analysis were applied. The analyzes confirmed a significant correlation between the recognition of benefits of playing football by women, the perception of the functioning of negative stereotypes and the sporting level of the groups distinguished. The 2nd and 1st League players associated practicing football with the possibilities for developing their personality traits, physical fitness and health, and promoting the discipline (in each case $p \leq 0.05$). All the footballers emphasized the risk of injury. The Extraliga players most often felt the stereotypical perception of female footballers as non-heterosexual ($p \leq 0.05$). Attribution of non-heterosexuality to female footballers was confirmed by self-government activists ($p \leq 0.05$). Women who played football showed a high tolerance toward non-heterosexual people. The Extraliga players were characterized by the highest tolerance ($p \leq 0.05$). CPEU activists represented stereotypical views on the selection of typically feminine sports. Among ten disciplines suitable for women, they did not list women's football.
There is an urgent need for public education to combat negative stereotypes concerning women practicing traditional male sports disciplines, as well as for tolerance toward people of a different sexual orientation.

Key words women's football, stereotypes, sexual orientation

Introduction

Female football has been an Olympic sport since 1996. Polish women who practice this sports discipline, regularly occur in the Champions League competition. In 2013 the under-17 female Polish national team won the gold medal at the European Championships (http://www.90minut.pl). Nevertheless, matches played by male teams are attended by crowds of fans, sometimes also stadium hooligans (Sahaj, 2012; Brzana, Nowak, Nowak, 2016), while women's games take place with nearly empty stands (Jakubowska, 2009).

Women involved in sports which are considered typical for men, are attributed with male characteristics, excessive muscularity, loss of femininity, neglecting the roles traditionally attributed to females (Mikołajczyk, 2003; Jakubowska, 2009). Sex is the most common basis for this stereotyping. Categories of femininity and masculinity are closely related, despite different patterns accepted in a given culture or era (Mandal, 2000). Patterns of femininity emphasize delicacy, sensitivity, shyness, protectiveness, thoughtfulness, care about appearance, and even coquetry. Patterns of masculinity underline dominance, rivalry, focus on success, feistiness, arrogance, self-confidence, physical fitness (Mikołajczyk, 1995**)**, aggression and brutality (Jakubowska, 2013).

Women who play football struggle with many problems and prejudices (Hively, El-Alayli, 2014; Jakubowska, 2012, 2015). Stereotypes also affect other sports that women try to practice. These disciplines are also referred to in literature as male sports or gender inadequate sports (Mazur, Organista, 2015). Stereotypes act as a preservative agent that maintains the existing state and inhibits changes in many spheres of life (Kofta, Jasińska-Kania, 2001), also in relation to football practiced by women (Andreis, 2012). One argument against women doing sports points to health considerations and difficulties in performing maternal roles. The evolution of social consciousness in recent decades has resulted in many sports disciplines, which so far were practiced only by men, becoming also available to women. Women can, for example, practice martial arts or combat sports and derive specific benefits from it (Boguszewski et al., 2015; Nowak et al., 2009, 2010). According to sports theorists, practicing typically masculine sports by women (combat ports, weightlifting, hammer throw, pole vault, ski jumping, mountain climbing, bodybuilding, team sports games, including football) can cause loss of health in the athletes. The reason for this situation may also be a shortage of specialized literature for optimizing women's training process (Bergier, 2009; Szark-Eckardt, Napierała, Kuska, Żukowska, Żukow, 2013).

One can agree with these opinions if we take into account only the biological roles of women. Numerous examples attest that women overcome these barriers and will continue to overcome them. Performing exercises on uneven bars (static and dynamic elements) requires tremendous coordination abilities and physical condition, not smaller than in the case of the mentioned pole vault. A performance on the bars involves supporting the athlete's body weight mainly on her arms in various positions throughout the duration of a dozen or more elements joined together in a dynamic manner (several seconds). Critical remarks concerning this sport as unsuitable for women, however, are not heard very often, as compared to, for instance, pole vault. One argument against females practicing 'masculine' sports disciplines is some women's 'strong' built. But when one reads a statement by a leading female shot putter, who ascertains that for her sport is a method of self-realization, finding a place where she belongs with her 'big body' among her friends, and getting rid of her complexes, it is not difficult to agree with her choice. The kind of built which predisposes a person to practicing e.g. shot put or hammer throw is naturally taken advantage of by choosing an appropriate sports discipline (Nowak, 2008). At the same time, the observed excessive exploitation of one's own body, including endeavors to reduce or increase its weigh (often with the use of pharmaceuticals), must be met with opposition, especially from pedagogues, physical education and sport theorists (Osiński, 2002) and physicians.

Women who practice team sports, especially footballers, face unpleasant stereotypes, prejudices and suspicions concerning their behavior, aggression, masculine physique, as well as sexual orientation (Andreis, 2012; Butler, 2008). Athletes who do not fit in heteronormativity are stigmatized, labeled (Jakubowska, 2013). Football is considered a 'male game', while women are placed on its margins (Jakubowska, 2015). Despite the obstacles encountered, in the 2014/15 season, 16,183 female football players were officially registered in Poland (Women's

Football Across the National Associations 2014–2015. UEFA Report). Young girls and women are attracted by physical activity which is linked to sporting rivalry, ability to work together and mutual understanding in fast-changing situations on the field. Football matches are accompanied by positive emotions which encourage them to practice this discipline.

The aim of the work was to learn about the conditions of practicing football by women and to determine positive effects and negative stereotypes accompanying this discipline, the basis being the opinions of female players as well as student self-government activists.

Research material and methods

The study was conducted among 100 female footballers from different leagues (Exstraliga, 1st League and 2nd League). The respondents were players of leading sports clubs in Poland. The study also included 31 activists (18 women and 13 men) of the student self-governments, who were present at the Congress of the Committee of Physical Education Universities (CPEU). Social characteristics of the female footballers and student self-government activists examined were presented in Table 1.

Table 1. Social characteristics of the respondents

Characteristics	Women who practice football			Student self-government activists	
	Exstraliga	1st league	2nd league	women	men
			%		
Number of subjects (n)	62	23	15	18	13
Age:					
Under 18 years old	31.2	40.9	12.5	–	–
18–24	47.5	27.3	81.3	83.3	92.3
25 and above	21.3	31.8	6.2	16.7	7.7
Place of residence:					
Countryside	83.6	81.8	62.5	83.3	84.6
City	16.4	18.2	37.5	16.7	15.4
Education:					
Secondary and below	37.7	50.0	12.5	–	–
Studying	34.4	27.3	62.5	77.8	76.9
Higher	27.9	22.7	25.0	22.2	23.1
Career:					
Yes	27.9	27.3	6.3	27.8	46.2
No	72.1	72.7	93.7	72.2	53.8
Marital status:					
Spinster	85.3	86.4	100.0	83.3	92.3
Informal relationship	13.1	13.6	–	–	–
Married	1.6	–	–	16.7	7.7

Most of the footballers were under 24 years of age. The players lived in cities, did not work professionally, studied. The student self-government activists were a bit older, mostly from cities and still studying. Male self-government members more often worked. Most of the footballers reported being single or in an informal relationship. The CPEU activists were single or married.

In the collection of the material, the diagnostic survey method was employed, with the use of the techniques of questionnaire, interview and participatory observation. For the statistical inference frequency of characteristics, the chi-square test of independence and multiple correspondence analysis were applied (van Buuren, de Leeuw 1992). These analyses are available in the statistical software package Statistica 12 [StatSoft, inc. 2015 Statistica for Windows]. For the correlations studied, statistical significance at the level of $p \leq 0.05$ was assumed.

Research results

In order to achieve the objective of the study, it was important to examine the opinions of the respondents regarding the division of sports disciplines into those intended solely for women and those intended solely for men. Most of the female footballers and CPEU activists accepted the division of sports into typically masculine and typically feminine (Table 2). In this group, the players from Exstraliga less often acknowledged the division (about 65% of the respondents for both classifications). More often it was the players from the lower leagues (1st and 2nd League) ($p \leq 0.05$ for the χ^2 test). The classifications of typically masculine and typically feminine disciplines produced by female CPEU activists did not differ statistically significantly from those produced by male activists.

Table 2. Recognition of the division of sports disciplines into typically masculine and typically feminine by the respondents (independence χ^2 test)

Respondents	Classification	
	masculine disciplines	feminine disciplines
	%	
Female footballers*		
Exstraliga	65.6*	64.0*
I league	91.9	91.9
II league	81.5	75.0
CPEU activist		
Women	66.7	55.6
Men	84.6	23.1

* Statistical significance at $p \leq 0.05$ was adopted.

The respondents named 10 sports disciplines most suitable for women and for men (Figure 1).

Based on an analysis of the frequency of characteristics, the sports disciplines were positioned hierarchically, ten points being given for the first place, nine for the second, etc. The footballers and the self-government activists similarly ranked disciplines which they regarded as appropriate for women. Synchronized swimming, gymnastics and ballet were the ones most often indicated by the players, as well as the CPEU activists, who also mentioned dancing as a typically feminine discipline. The players put football in the eighth place. The CPEU activists did not consider this discipline to be suitable for women, as well as figure skating. All the respondents indicated combat sports and rugby as the most appropriate for men. In the view of the women who practiced football, next on the list were ski jumping, water sports and motor sports. For the CPEU activists, American football, weightlifting and martial arts were more 'masculine' sports. Football as a sport intended only for men was ranked tenth.

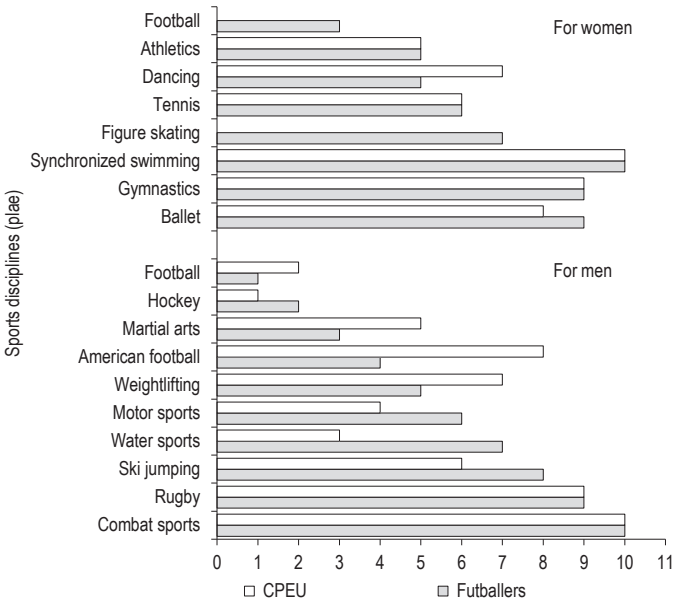

Figure 1. Kinds of sports disciplines intended solely for men and solely for women in the opinion of the respondents (%)

In the analyses concerning the conditions of practicing football by women, opinions of the CPEU activists were compared with those of the female players (Table 3).-

Table 3. The conditions of practicing football by women in the opinion of female footballers and student activists (independence χ^2 test)

Specification	Women who practice football (n = 100)			Student self-government activists (n = 31)	
	Exstraliga	1st League	2nd League	women	men
			%		
Equality	17.7	22.7	12.5	33.3	38.5
Freedom to choose	21.0	9.1	–	27.8	23.1
Promotion of the discipline	24.2*	40.9	68.8*	50.0	23.1
Physical fitness and health	25.8*	45.5	56.3*	61.1*	23.1
Development of personality	25.8*	27.3	68.8*	77.8	53.9
Fighting stereotypes	29.1	–	6.3	38.9	15.4
Injuries	85.5	81.8	87.5	38.9	53.9
Accusation of different sexual orientations	65.0	45.5	50.0	61.1*	23.1

* Statistical significance at $p \leq 0.05$ was adopted.

The respondents stressed that practicing football by women was possible due to equality (38% of the footballers examined). Women's football national and world competitions are held, with separate sport classifications. Equality is connected with the freedom to choose (35% of the responses) this discipline from a wide range of sports, because it satisfies the need for intensive physical activity, teamwork and experiencing many positive emotions. As far as these factors are concerned, no statistically significant differences were observed. For 35% of the respondents it was also important to promote football among girls. The 2nd League players attached more importance to this opportunity ($p \leq 0.05$ for the χ^2 test). The need for the promotion of football was also recognized by 38.7% of the CPEU activists, who did not, however, place it among the disciplines which according to them were the most suitable for women (see Figure 1). In the opinion of 35% of the female footballers and 45.2% of the CPEU activists, practicing football was beneficial in developing physical fitness and health. These effects were most often appreciated by the 2nd League players ($p \leq 0.05$ for the χ^2 test) and the female CPEU activists ($p \leq 0.05$ for the χ^2 test). Development of personality traits through practicing sport was also important. This indirect effect of engaging in competitive sport was noticed by 33% of the female players, most often from the 2nd League ($p \leq 0.05$ for the χ^2 test), and 67.7% of the female CPEU activists.

For 38% of the female players, practicing football meant resistance to the stereotype according to which football was a typically masculine sport. The existence of this stereotype and the necessity to fight it was emphasized the most by the Extraliga players, who had been training the longest, and had the greatest sports achievements. In individual utterances, they said that they constantly had to prove their specialized and tactical skills, delight with their psychophysical condition, and impress with their commitment both during practices and matches. A distinctly felt negative effect of practicing football by women was frequent injuries, mentioned by most players regardless of their sporting level (85%). The risk of injury was assessed as over twice as low (33%) by the CPEU activists. The women who practiced football encountered various prejudices concerning their possible sexual orientation. They were perceived by the players from all the leagues (57% of the total), as well as the CPEU activists (45.2%); more often the female ones ($p \leq 0.05$ for the χ^2 test).

Detailed data illustrating the issue of female footballers being perceived as non-heterosexual by their closest environment were shown in Table 4.

Table 4. Attitudes of female footballers and CPEU activists toward non-heterosexuality (independence χ^2 test)

Respondents	Non-heterosexuality of female footballers		
	yes	no	I do not know
	%		
Female footballers			
Exstraliga	65.0	15.0	20.0
1st League	45.5	13.6	40.9
2nd League	50.0	12.5	37.5
CPEU activists			
Women	61.1*	27.8	11.1
Men	23.1	23.1	53.9

* Statistical significance at $p \leq 0.05$ was adopted.

Opinions confirming the functioning of this negative stereotype dominated among 58.2% of all the players and 45.2% of the CPEU activists. The female CPEU activists were more often (61.1%) aware of its existence ($p \leq 0.05$ for the χ^2 test).

The respondents female footballers showed various attitudes toward non-heterosexuals (Figure 2).

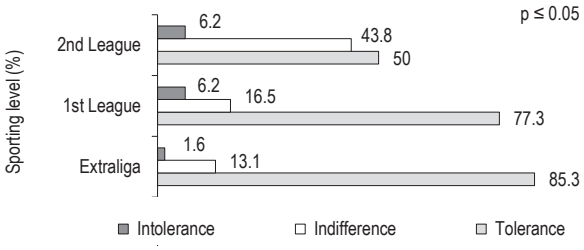

Figure 2. Attitudes of female footballers toward non-heterosexuality (independence χ^2 test)

There was a statistically significant relationship between tolerance toward non-heterosexuals and the subjects' sporting level ($p \leq 0.05$ for the χ^2 test). The players who were at the highest sporting level (Exstraliga and 1st League) were characterized by the highest level of tolerance toward non-heterosexual people (85.3% and 77.3% resp.). The 2nd League footballers more often showed indifference (43.8%). Few players declared intolerance toward people of a different sexual orientation.

The CPEU activists' attitudes toward non-heterosexuals did not differ significantly. The female activists were characterized by a higher level of tolerance toward different sexual orientations (72.2%) in comparison with the male ones (38.5), among whom the numbers for the indifferent and the intolerant attitudes were similar (30.8% each).

The diverse circumstances accompanying practicing football by female players from Exstraliga, 1st and 2nd Leagues were presented in Figure 3.

Multiple correspondence analysis based on Burt tables was used. From all characteristics, two dimensions were selected for the analysis (the first and the second), which were represented by co-operating variables. These dimensions explained 37.47% of the total value of χ^2, including the first dimension: eigenvalue = 0.29, inertia percentage = 22.53%, and the second dimension: eigenvalue = 0.19, inertia percentage = 14.94%. For graphical analysis, three groups were isolated: female footballers from Extraliga (E), 1st League and 2nd League. The Exstraliga players (E) pointed to the frequent injuries accompanying the practicing of the sport the most (4a). They saw the existence of stereotypes concerning the discipline they practiced and underlined the need to fight them (5a). The Extraliga players most often felt that female footballers were perceived as non-heterosexual (6a). The players with the highest sporting level (E) to a lesser degree associated practicing football with the opportunity to develop physical fitness and health (2b) or promote the discipline (3b). The last mentioned factors, however, were emphasized by the 1st League players, in whose opinion practicing football created possibilities for developing physical fitness and health (2a) and promoting the discipline (3a). The 1st League players more rarely treated practicing football as a form of fighting stereotypical beliefs (5b) of the closest environment. Even though nearly half of the 1st League players felt that female footballers were perceived as non-heterosexual (45%), the rest of them

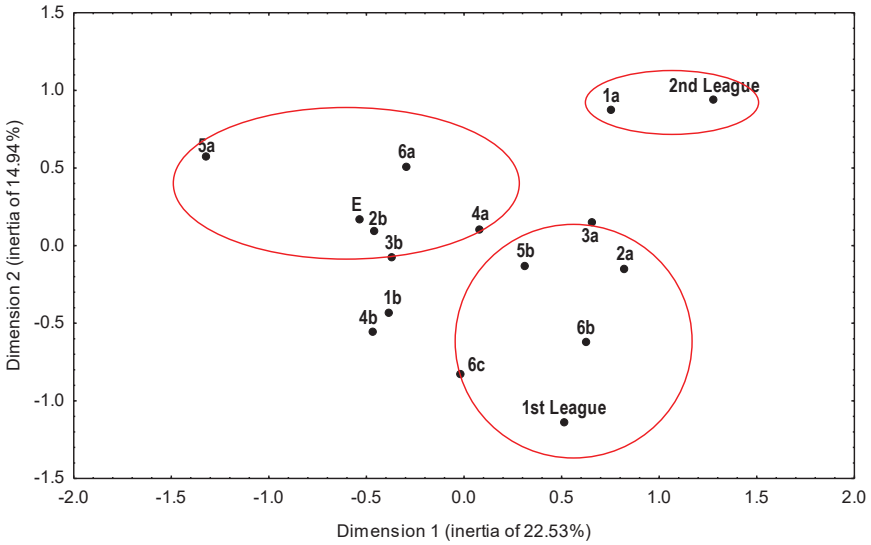

Figure 3. Relationships between the conditions of practicing football by women and their sporting level (multiple correspondence analysis)

were not familiar with this phenomenon (6b, 6c). Practicing football had the greatest influence on the development of personality traits in the opinion of the 2nd League players (1a). The footballers from the highest leagues (E and 1st League) to a lesser degree associated practicing football with the opportunity to develop their personality (1b) and the lack of injuries (4b). The analyses confirmed a statistically significant correlation between perceiving benefits of practicing football by women (mainly 2nd and 1st Leagues), pointing to the functioning of negative stereotypes (mainly Exstraliga) and the sporting level of the particular groups.

Discussion

Women today have full access to education and professional work, although their salaries are still lower compared with those of men with similar education and competencies. Women may also participate in public and political life, but the weight of their choices, which may cause traditional role conflicts, is emphasized (Mikołajczyk, 2003). The role of women in society is closely connected with the situation in sport, where there is no clear and explicit discrimination against women. Evidence of progressive changes might be seen in the inclusion of a growing number of sports available to women in the Olympic Games program. Equal rights for women are also guaranteed by the Constitution of the Republic of Poland (Konstytucja Rzeczypospolitej Polskiej, 1997). It is worth noting that the Statute of the Polish Football Association contains a clause on the prohibition of discrimination. It reads as follows: "§ 2. Any discrimination against a country, an individual or a group of people with regard to the organization or practice of the sport of football for reasons of ethnicity, gender, language, religion, political beliefs or any other reasons is explicitly prohibited under the threat of disciplinary sanctions, including suspension or exclusion from the Association" (Statute of the PFA Art. 7, Neutrality and non-discrimination, https://www.pzpn.pl/public/635/47). At the same time, the membership of girls and women in sports clubs participating in sports competitions organized

by the Polish sports associations amounted to about 12%-14% in the previous years, while female football players accounted for 0.8–2.8%. The sport was more often practiced by juniors (1.2–5.3% of all footballers) than senior players (0.5–1.1%) (Włoch, Skóra, Szankin, Szeptycka, 2013). Own research involving people from different leagues, also indicate a significant number of juniors.

The literature stresses the negative impact of sport on women's health, connected for example with the inadequacy of sporting regulations, techniques and training load, which do not take into account women's physiological capabilities. Part of the explanation for this phenomenon is the situation in sport. The decision-making positions in sports organizations and institutions are occupied mainly by men. This is true in all Western countries, Australia, the USA, and in Poland as well. Increasing women's participation in the governing bodies of sports organizations could have a lot of positive effects and bring about more adequate solutions in the field of women's sport. Such changes are called for by, among others, T. Socha (2002), G. Pfister, (2003/2004). Recent research has shown that gender inequality is manifested in the appointment of offices in Polish sports organizations (such as offices of presidents, vice presidents, chairpersons and vice-chairpersons of committees). Fewer women work in Polish organizations than in international and British ones; there are also fewer women in women's sport committees (if they have been created). More women work in organizations that are traditionally considered feminine (Organista, 2017).

There is no doubt, however, that women's capabilities of holding executive positions have some limitations. These include: individual factors (competencies, motivations, priorities, attitudes acquired in the process of socialization – leadership qualities, the ability to fight for prestige, etc.), time budget, material resources (ability to work, support from the family and partner, the influence of the community, important contacts and connections), genuine or perceived conflicts between the career in sport and other spheres of life (partner, children). Women's opportunities for occupying managerial positions are seriously limited by their family situation. The existing gender inequality in this respect is not a sign of the struggle with men, but an attempt to identify the social and cultural background and get to know the logic of decision-making processes **(**Gieß-Stüber, 2000).

One of the most important values in modern Western societies is the freedom to individually choose a lifestyle, and shape and recognize different desires and aspirations (Hively, El-Alayli, 2014; Jakubowska, 2009, 2015). Women make these choices and take on various challenges, also in the field of sport. Most female players recognize the division into typically masculine and typically feminine sports disciplines. The Exstraliga players less often accept the division. Acknowledged are those disciplines (synchronized swimming, gymnastics and ballet), which serve the image of a modern women. Even female footballers listed football as low as in the eighth place. This testifies to the strong influence of this stereotype and to female footballers being subject to it, despite their declared endeavors to fight the phenomenon. As far as the CPEU activists' ranking of ten sports disciplines is concerned, they did not mention football as a discipline suitable for women, but they placed it only in the 10th place among sports for men. Problems of women who practice competitive sport, which are also related to stereotypes, are addressed, among others, in the 2012 Social Project study (Włoch, 2013).

In the opinion of female players and student government activists, injuries were the most negative aspect of practicing football by women. Comparing the discipline with others, one can venture to say that no discipline is free from injuries. Their number does not depend solely on the vulnerability of women, but rather on the kind of training system (Niewolna, Zwierko, 2016), training conditions, physical rejuvenation forms (Chudecka, Lubkowska, 2010) and medical care. Injuries affect all athletes in many sports disciplines, regardless of gender. In epidemiological

studies conducted between 1990 and 2003 among girls and boys who practiced football, it was observed that women suffered more injuries than men (in absolute figures). The most commonly injured parts of the body in girls were upper and lower limbs (wrist, finger, hand, ankle, knee). Girls were more likely to suffer from ankle joint injury than boys, who more often had head and neck injuries (Leininger, Knox, Cumstock, 2007).

The late 20th and early 21st centuries have been the time of intensive change in sexual mores, connected with civilizational transformations, development of biological sciences, and increase of knowledge concerning human sexuality. This knowledge, along with civilizational changes, became the impulse for the sexual revolution, which is characterized by tolerance towards premarital sexual activity, cohabitation, diverse sexual orientations, and sex education (Marczak, 2011). In every culture, in every society there are certain stereotypes related to sexuality. They include athletes as well. For women engaged in football, being perceived as non-heterosexual is particularly painful. The reason for this unpleasant stereotype is practicing football, which is often regarded as a typically masculine discipline, as it was described above. The studied female footballers also had difficulty freeing themselves from this stereotype; they classified this discipline partly as typically masculine. This situation demonstrates the strength of the stereotype. The opinions of the players and CPEU activists testify to the existence of the malicious stereotype concerning non-heterosexuality among women who practice football. The issue of non-heterosexuality is most often mentioned in connection with 'masculine' sports. Attribution of this orientation to women (whether rightly or not) is a way to protect what is 'masculine' from what is 'feminine' (Jakubowska, 2014).

Z. Izdebski (2011) examining attitudes toward sexual minorities, found that the views of Polish people are not free from myths and stereotypes. Almost 2/3 of the adult respondents (18–49 years old) said that sexual contacts between persons of the same sex are not normal. In the group of people over the age of 50, in a study of tolerance toward non-heterosexuals it was found that almost half of the respondents expressed the opinion that they had nothing against non-heterosexual people if they do not demonstrate it (Izdebski, 2011). Homophobia is one of the most important problems faced by contemporary sport, but in Polish sport it is not mentioned (Jakubowska, 2014). The more valuable are the attitudes of female footballers, who were characterized by a high tolerance toward non-heterosexuality; it was higher among the players from the two highest leagues.

In some studies, it was emphasized that the majority of women who practiced football at the national level had an androgynous gender identity. It could be assumed that this personality type allows optimum adaptation to the conditions of functioning in football, but also in other sports disciplines (Soroka, Bergier, 2011) as well as in various areas of life.

In conclusion, it is worth noting that only some sports associations raise the issue of discrimination on grounds of gender in their statutes (Włoch, 2013). The clause in the Statute of the Polish Football Association on the prohibition of discrimination for the reason of gender with regard to practicing football, testifies to the recognition of this problem by sports authorities and activists.

Conclusion

1. The condition of practicing football by women is not only the issue of equal rights and freedom to choose discipline, but still- the need to combat negative stereotypes.

2. The 2nd League players most often indicated the following benefits of practicing football by women: opportunity to develop their personality, developing physical fitness and health and promoting the discipline among women. The Exstraliga players pointed to the frequent injuries accompanying the practicing of the sport.

3. The opinions of the players (mostly of the Exstraliga players), as well as CPEU activists point to the functioning of the negative stereotype concerning the non-heterosexuality of women practicing football. Despite the functioning of the stereotype, the women from higher leagues were characterized by a higher level of tolerance toward non-heterosexuality.

4. There is an urgent need for public education to combat negative stereotypes concerning women practicing traditional masculine sports disciplines, as well as for tolerance toward people of a different sexual orientation.

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LIFESTYLE VERSUS A PERSON'S LIFE SPAN

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Abstract Numerous studies indicate that a person's lifestyle has a positive impact on their health. However, in spite of the predominant anti-health lifestyle, the average length of life in the past few decades has increased.
What is the relation between a lifestyle and life expectancy? Does the lifestyle affect human life span?
Epidemiological and prospective-retrospective studies were used to evaluate a 20-year long population-based experiment, which involved in-depth studies, analyses and evaluations of three related families who resided in the same community, had the same education level, and the same period of socialization and tradition. To evaluate the collected research material, the authors used their own: Scale for evaluating nutrition habits; Criteria to assess health behaviours of subjects; Criteria for diet assessment.
The studied families led a similar lifestyle, with prevalence of anti-health behaviours. Theoretically, subjects should live a similar number of years. However, the length of their lives varied. Members of families with higher number of anti-health factors lived, in fact, longer.
The authors confirmed the hypothesis that the lifestyle of the examined families was an important contributor to their health, but certainly it was not the only factor to determine their life expectancy. The length of lives of the examined family members varied despite a similar lifestyle.

Key words lifestyle, health behaviours, life expectancy, old age, family

Introduction

The subject-matter literature reveals that good health (caring for one's health) determines a long life (Frąckiewicz, 1989, 1999; Ostrowska, 1999; WHO, 2011; Sygit, Sygit, 2008; Sygit, 2010).

Health is influenced by many factors, presented in the so-called Lalond model. These are: lifestyle (about 52%), physical environment (20%), genetic conditioning (20%), and health care (8%) (Sygit, 2010; Kulik, Pacian, 2014).

Healthy lifestyle has the biggest positive effect on health, i.e. rational nutrition, physical activity, rest, stress avoidance, refraining from smoking tobacco and drinking alcohol (Ostrowska, 1999; Sygit, 2010; Bouchard, Blair, 2007; Flatcher, Balach, Blair, 1996; Karski, 2003; Kosińska, 2006). The most important factors from the above-mentioned are: physical activity and rational nutrition (including reduced consumption of high-fat products (pork) in favour of white meat (fish, poultry) (Sygit, 2010; Kosińska, 2006; Booth 2000; Craig et al., 2003; Ekelund et al., 2007; Gawędzki, Hryniewiecki, 1988; Gill, 1997; Horst, Paw, Twisk, Van, 2007).

Health education promotes, or even appeals for, physical activity and preventive medical check-ups (Frąckiewicz, 1999; Booth, 2000; Craig et al., 2003; Jarosz, 2006; Nawojek, 1993; Drabik, Resiak, 2010; Gorret, 1990).

The importance of a healthy lifestyle has become the subject of a number of studies and analyses which encompass populations of all ages (Jabłoński, 1998). Many studies have shown that the level of physical activity, which is the foundation of human health, was very low (Janssen, 2007; Kalman et al, 2015; Karasek, 2003; Siciński, 2002; Snitor, Krak, 2007). It has also been found that nutrition habits were irrational and there were many anti-health factors (such as smoking, drinking alcohol, chemical stimulants) and environmental factors present. Nevertheless, it is observed that the average life expectancy of a person is increasingly longer. Over the past decades, there has been a significant increase in life expectancy in Poland. Currently, the average life span of a woman is 81.6 years, while for a man it is about 73.8 years. In other countries, such as Japan, the average is 91 years (Ostrowska, 1999; Wrzesiński, 1993; Frączak, 1984; Pędich, 1995).

Some literature findings indicate that – in spite of the continued prevalence of anti-health factors – the population has lived longer and longer over the past several decades (Frąckiewicz, 1999; Janssen, 1998; Kalman et al., 2015).

Human longevity research brings new insights and brings us closer to answering the question: What to do and how to live to be 100 years and more?

The aging process is still undiscovered. There are many theories of aging. We do not know, however, what determines the length of a person's life (Frąckiewicz, 1999; Sygit, 2010; Sygit, 2009).

The purpose of this paper is to find an answer to the following question: How does lifestyle affect the lifespan of a person?

Monitoring a person's lifestyle over a long period of time (especially in a form of family studies) can bring us closer to identifying a recipe for longevity.

The following hypotheses were made:

– it is assumed that lifestyle is the main determinant of a person's lifespan, as it significantly affects their health,
– it is assumed that people who have similar lifestyles, residing in the same environment, related to one another, doing the same type of work and having similar education level, would display similar health and reach similar life expectancy.

Materials and methods

Prospective-retrospective study was used to assess a 20-year long population-based experiment, involving three related families which resided in the same community (a village in Kujawy, Poland) (Table 1).

Table 1. Summary of families

Family	Wife	Husband	(Number of) children	Grandchildren	
				men	women
1	A	A1	6	3	5
2	B	B1	1	3	1
3	C	C1	1	–	1
Total	3	3	8	6	7

The analysis focused in particular on:

- data collected from the family members on their daily lives,
- information from various documents held by the families,
- information collected from living members of the families (children and grandchildren),
- interviews and opinions of friends, neighbours, including own autopsy,
- results of studies, analyses and observations collected in the course of study.

Criteria for assessing health behaviours (Table 2) were developed to assess health behaviours of the subjects (including their predominantly anti-health behaviours).

Table 2. Criteria used to assess health behaviours of subjects

Number	Applied criteria
1.	Smoking (at least 10 pcs. daily)
2.	Drinking alcohol (at least 100 g daily)
3.	Consumption of red meat (pork, beef) at least 3 times per week
4.	Physical activity (working in the field, on the farm – daily)
5.	Consumption of vegetables, fruit, salads (at least 3 times per week)
6.	Performing preventive medical check-ups (at least every second year)
7.	Excessive salting of food (frequent)

A scale for assessment of dietary habits was developed to evaluate nutrition routine of the subjects (Table 3).

Table 3. Scale for evaluating nutrition habits

Number	Independent variables	Number of families that were rated	
		positively (A)	negatively (B)
1.	Daily consumption of		
2.	Breakfast		
3.	Elevenses		
4.	Lunch		
5.	High tea		
6.	Dinner		
7.	Snacking between meals		

To assess subjects' weekly diet, criteria for evaluating the diet (Table 4) were developed.

Table 4. Criteria for diet assessment

Criteria	Of the assessment		
	very good	good	sufficient
Carbohydrates	3 times per day	3 times per day	3 times per day
Protein	3 times per day	2 times per day	Once per day
Fats	2 times per day	Once per day	3 times per day
Vitamins and minerals (fruit and vegetables)	1–3 times per day	0–2 times per day	0–1 per day

In total, 100 menus per year were assessed during the study period. The collected data, observations, interviews and autopsy data provided an unbiased overview of the weekly dietary habits, lifestyle characteristics and description of family history of all three families.

Results. Commentary

1. The overview of the subjects

The study which is being described in this paper, included three related families living in their homes (farms) in the countryside, as neighbours. The families were a rare case, and thus they became particularly interesting due to their life histories and objective assessment.

These families included:

1. Three sisters (W) who got married with three brothers (S):
   - family of the sisters: 4 sisters and 1 brother,
   - family of the brothers: 4 brothers and 1 sister.
2. Observations and analyses focused on the three women (sisters) from the W family who married three men (brothers) from the S family.

Parents of the women (sisters) died at the age of 60 (father) and 52 (mother). Parents of the men (brothers) died at the age of 65 (father) and 63 (mother). Parents of brothers (men) were healthy, while the mother of sisters (women) was ill (probably with diabetes).

1.2. Body mass of women and men:
- all women (sisters) were obese (BMI > 30),
- the men (brothers) had correct body weight, they were thin, without a trace of overweigh (BMI < 24).

1.3. Diseases in the surveyed families:
- Family 1 had hypertension (A1), (A) and diabetes (A),
- Family 2 had (a probable) prostate cancer at the end of life (B1). By contrast, (B) was never ill. At the end of life, she fell and fractured her hip. She had never been to a doctor before that,
- Family 3 (C) suffered from diabetes, followed by total blindness, (C1) was not ill.

1.4. Diseases of children in the surveyed families:
- Family 1 – son and daughter suffering from diabetes,
- Family 2 – the only son had hypertension, while his three sons are diabetic,
- Family 3 – daughter (a single child) suffered from diabetes, while her children are healthy (Table 5).

Table 5. Diabetes among children in the surveyed families

Family	Women	Men	Total number of children
1	–	1	6
2	–	–	1
3	1	–	1
Total	1	1	8

2. Lifestyle of the families

2.1. Health behaviours of the subjects. The health behaviours of the family members were assessed with certain criteria (Table 4) to identify the prevalence of anti-health behaviours. The assessment showed a high incidence of these behaviours (i.e. disease risk factors), especially those related to red meat consumption, adding salt to dishes and skipping preventive medical check-ups. The number of anti-health behaviours was higher among men (husbands) than women (wives). The assessed pro-health factor was physical activity (daily hard work in the field and on the farm, which provided a lot of physical stimulation) (Table 6).

Table 6. Anti-health behaviours of the families

Number	Independent variables	Family members	
		women	men
1.	Smoking tobacco	–	1
2.	Drinking alcohol	1	1
3.	Consumption of red meat (pork, beef)	3	3
4.	Low physical activity	1	–
5.	Consuming fruit, vegetables and salads less than 3 times per day	2	1
6.	Skipping preventive medical check-ups	1	3
7.	Adding salt to dished (excessive salting)	2	3
Positive assessment		–	–
Negative assessment		+ negative	+ negative

Criteria for assessment:
– 4 negative factors – negative score,
– 3 negative factors – sufficient score,
– 2 negative factors – good score.

Only one man smoked tobacco (and drank alcohol), while only one woman drank alcohol – 100 g of pure spirit daily at dinner.

Nutrition habits of the subjects.

A scale for assessment of dietary habits was developed to evaluate nutrition routine of the subjects (Table 6).

Families consumed 3 meals daily: breakfast, lunch and dinner. They did not have elevenses or high teas. The times of meals were not the same (meal times and times between meals varied), as meals depended on their work. The number of negative scores exceeded the number of positive ones (Table 7).

Table 7. The assessment of nutrition habits of the subjects, according to the assessment scale

Number	Independent variables	Number of families that were rated		The number of positive and negative scores
		positively (A)	negatively (B)	
	Daily consumption of			
1.	Breakfast	3	0	p > n
2.	Elevenses	0	3	p < n
3.	Lunch	3	0	p > n
4.	High tea	0	3	p < n
5.	Dinner	3	0	p < n
6.	Snacking between meals	1	1	p = n
7.	Frequency of meals	1	2	p < n

Favourite (preferred) meals were: lunch, breakfast and dinner. Dominant food product and dishes were: bacon, pork, potatoes, bread, pancakes. Unpopular products were: salads, fruit, fish and cakes. The distribution of favourite foods and meals was very similar among the families (Table 8).

Table 8. Preferred foods, meals, dishes

Preferred (favourite)	Families		
	A	B	C
Breakfast	+++	+++	+++
Lunch	+++	+++	+++
Dinner	++	++	+++
	Products		
Bacon	++	+++	++
Lard	+++	++	+++
Pork	+++	+++	+++
Poultry	++	++	++
Milk	++	++	++
Potatoes	+++	+++	+++
Bread	+++	+++	+++
Groats	++	+	++
Salads	+	+	+
Fruit and vegetables	+	+	+
Fish			
	Dishes		
Pierogi dumplings	++	+	+
Pancakes	+++	++	+++
Cakes	+	+	+

Criteria for assessment:
- very high degree of preference = +++,
- moderate degree of preference = ++,
- low degree of preference = +.

The sum of ratings: there were 20 very good scores, 13 good scores as 11 low scores.

The criteria used to evaluate selected weekly menus from every 100 menus evaluated each year showed that most of them received 'very good' scores, some received 'good' scores, while few received 'sufficient' scores. (Table 9).

Table 9. Summary of average scores for selected weekly menus of the families

Family	Number of menus which were rated: average values			Number of rated days per week
	very good	good	sufficient	
1	3	2	2	7
2	4	2	1	7
3	4	2	1	7

On average, the subjects consumed carbohydrates (mainly bread) 3 times per day; proteins (dairy products, smoked meat) were not always consumed 3 times per day; while fats were consumed 3 times per day (mainly in the form of bacon and lard), but not all menus included them 3 times per day. Salads and fruit were eaten rarely (salads were limited mainly to sauerkraut and cucumbers).

3. Length of life

The length of a person's life is undoubtedly dependent on many factors, amongst which the state of health (i.e. not only the lack of disease but a set of psychophysical factors) plays an important role. In turn, the state of health depends – according to Lalond – in up to 50% on the individual's lifestyle. A positive lifestyle is, to some extent, a guarantee of a long life. The life expectancy of men in Poland in 2015 increased by 0.7 year to 73.8, and of women by 0.5, to 81.6.

The lifestyle of the subjects (members of the families) was similar. They experienced diseases, especially women. These diseases were: diabetes in women (A) and (C), as well as hypertension in men (A1) and women (A).

All women were obese.

The longest-living woman (B): 86 years old, never sick, obese, not physically active, drank alcohol (every day). Her sisters lived much shorter lives. She was the only one without diabetes. Among men, (A1) had the longest life: he was thin (like other brothers), but unlike them, he drank alcohol (several times a week) and smoked a lot (about 15–20 cigarettes a day) (Table 10).

Table 10 Subjects' length of life

Family	Length of life (years)		Total years of life of family members
	wife	husband	
1	A 82	A1 72	154
2	B 86	B1 64	150
3	C 72	C1 66	132
Total years of life	240	202	442

The length of life varied despite similar lifestyles of both men and women in the families. A comparison of length of life of the family members showed that: Family 1 had the highest total of years lived; the amount was

insignificantly higher than in Family 2, and significantly higher than in Family 3. The sum of years of life of women (sisters) in the families was 38 years higher than the sum of years of men's life. These results confirm a large variation in the length of lives among families and among women (wives, sisters) and men (brothers, husbands), despite similar standards of living, living environment and similar life conditions (standard of life).

Discussion

The results of longitudinal studies on lifestyle, health and length of life have not been presented in the literature so far.

Long-term studies and observations of families, including their members living in the same environment, related to each other, leading a similar lifestyle and having similar work (agriculture), bringing up children, may be an important contributor to the knowledge on epidemiology of the prevalence and spread of particularly chronic diseases in terms of the influence of external, environmental, and personal factors on one's health and life expectancy. Research on families who live in similar conditions may help answer questions about a person's life style versus their life span (Bouchard, Blair, 2007; Flatcher, 1996; Ekelund et al., 2007).

The presented results of a 20-year long study on Polish families living in a rural environment with similar lifestyles, related to each other, provided interesting observations. Many results point to the anti-health lifestyle of the population, on the basis of which the future health of the population is forecast. At the same time, we experience a civilization progress, improvement of living standards, increase of the average life expectancy and developments related to certain health conditions (Halicka, Pędich, 1997; Pędich, 1965; Piotrowski, 1973; Karski, Pawlak, 2003; Miker, Gębska-Kuczarowska, 1988). So, what is the role and importance of a lifestyle?

The 20-year long observation leads us to believe that: in families with a similar lifestyle (similar nutrition, physical activity, leisure) theoretically the wives (sisters) and their husbands (brothers) should live a similar number of years. However, there were significant differences, which may indicate other factors responsible for life expectancy. In the studied families, men from families without chronic diseases (including diabetes) were not ill, and enjoyed good health (one of the men had mild hypertension).

Analogically, women from a family with chronic diseases (diabetes) had diabetes as well. One of them was not ill. They were obese throughout their adult (married) life.

How were the subjects different?

As for the women (sisters), they all came from a family with diabetes, had a similar lifestyle, and were not hospitalized. One of them was not diabetic, but was the least active physically; she never had any health issue and did not require treatments. She drank a glass (about 100 g) of pure spirit every day. Her only son was not diabetic, but his three sons are all diabetic. She lived the longest among the sisters and among all subjects in the family.

As for men: they all had healthy parents, led a similar lifestyle, and were very physically active. They were healthy and did not suffer from diabetes. One of them drank alcohol (several times a week) and smoked cigarettes. He had hypertension. He lived the longest of all the brothers.

Theoretically, the sisters (wives) and brothers (husbands) should live a similar number of years. The differences in the length of their lives were related to their health. Members of families with higher number of risk factors (alcohol, tobacco) lived, in fact, the longest. All the subjects lead a similar lifestyle (in most cases, it was not healthy) and yet women who were obese and (two of them) had diabetes lived longer than men (their husbands) who also had similarly unhealthy habits, but lived much shorter, even though they did not suffer from obesity or diabetes.

Studies on longevity indicate cases of smoking (but often the tobacco came from subjects' own farm: *Nicotina tabacum*) and alcohol consumption of the long-living individuals (Ostrowska, 1999; Manton, 1998; Klonowicz, 1979; Synck, 2002). The lack of similar observations (and family studies) in the long perspective makes it impossible to compare the cases, but sheds some light on the role of lifestyle and its importance for human life. Researchers are aware that the observations, despite a 20-year period and only three families involved (although their situation was dictated by life, and therefore used in the experiment) do not allow for generalizations, but are a significant contributor to further research.

Conclusions

Based on the results obtained from 20-year long observations and studies on lifestyles and life expectancy, it was found that:

1. The authors confirmed the hypothesis that the lifestyle of the examined families was an important factor of their health, but certainly it was not the only one (and possibly not the key factor) to determine their life expectancy.
2. Life expectancy of the family members was varied despite their similar lifestyles.
3. Anti-health behaviours were dominant in the lifestyle of the subjects.

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SPORT-RELATED TRAUMATIC INJURIES AMONG SCHOOLCHILDREN (A QUESTIONNAIRE STUDY)

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Abstract Background: Childhood represents a risk period of susceptibility to sport-related injuries.
Objectives: The aim of the study was to investigate the prevalence of sports-related injuries including orofacial traumas in children attending primary schools and participating in competitive sports, then to compare their situation with that of children engaging in sporting activities only at school and in their leisure time. The second aim of the study was concentrated on the use of sports mouthguards.
Methods**:** Data was obtained by means of a questionnaire and statistically analysed by the basic statistic methods in Microsoft Office Excel and Pearson's chi-square test, and a statistical significance level $p < 0.05$ was established.
Results: 341 children (175 girls and 166 boys) completed the questionnaires and 204 (59.8%) of them were competitive athletes. 146 (42.8%) children reported sports-related injuries and 47 (13.8%) children registered trauma of the orofacial region. Only 10 (2.9%) children regularly use sports mouthguards. No statistically significant differences were detected in the occurrence of sport-related injuries including orofacial traumas between the competitive athletes and non-competitive children.
Conclusion: Sport-related trauma represents a risk not only for children engaging in competitive sport activities but also for children doing sports at school and occasionally in their free time.

Key words dental trauma, dentoalveolar trauma, sport mouthguard

Introduction

Childhood represents a high risk period in terms of susceptibility to injury. Children may cause themselves not only serious injuries which result in hospitalisation, in some cases invalidity or even death, but also non-life-threatening injuries in the orofacial area. Injury or invalidity, especially if it involves movement, the human senses or physical appearance, often leads to intense anxiety and stress, which threatens the healthy creation of a personal identity. Injuries to the face, jaw, oral cavity and teeth are problems which in the long term worsen the quality of life of the child and burden the family financially (Poritt, Dawn Rodd, Baker, 2011). Traumatic dental injuries (TDI) account for 5% of all injuries for which medical advice is sought; in the case of pre-school children the figure is as

high as 17% (Andersson, 2013). Dental trauma in children most occurs in the period of growth and development of the orofacial area; treatment is often complicated, long-term and requires special care.

The literature provides various data concerning dental injuries in children. It is stated that 50% of adolescents have experienced dental injuries (Andreasen, Ravn, 1972). Authors from northern countries describe how 35% of minors aged 16 have had one or more dental injuries during their school attendance (Borsen, Holm, 1997).

Recent years have seen an increase in the number of injuries involving teeth and jaw in children. The causes of dental injuries may be divided into the unpredictable (falls, collisions, blows to the orofacial region) and the predictable, which include injuries sustained during sports activities. The most common causes of dental injuries include falling whilst running, tripping up or slipping, as well as being struck in the mouth by objects, various sports activities, traffic accidents and, in rare cases, the result of violence (Atabek, Alaçam, Aydintuğ, Konakoğlu, 2013; Glendor, 2008; Hecova, Tzigkounakis, Merglova, Netolicky, 2010; Lexomboon, Carlson, Andresson, von Bultzingslowen, Mensah, 2016). The situations described above account for 61% of dental injuries in children (Glendor, 2008). Damé-Teixeire (Damé-Teixeire, Severo Alves, Susin, Maltz, 2013) ascertained that from a group of 1528 12-year-old children, the most common cause of injury was a fall (15.46%), followed by sport (11.08%) and various collisions (10.6%). A further frequent cause of dental injuries in children are various games (16.2%) and sports activities (between 11.1% and 39%) (Glendor, 2008; Hecova et al., 2010; Lexomboon et al., 2016; Damé-Teixeire et al., 2013). Other, less frequent causes of dental injuries in children are traffic accidents, fights and acts of violence (Damé-Teixeire et al., 2013). Children may cause self-inflicted dental injuries through various bad habits such as chewing on pencils or using their teeth to open hair-clips or remove bottle tops. Such behaviour accounts for between 3.3% and 8.5% of dental injuries (Traebert, Peres, Blank, Boell, Pietruza, 2003; Taiwo, Jalo, 2011). Dental injury may also be due to iatrogenic causes, which include laryngoscopy and intubation (Glendor, 2008).

The most frequent location where children sustain dental injuries is the home (22.3–63.2%), followed by school (8.5–36.0%), children's playgrounds, including sports grounds (20%), and the street (11.2–12.0%) (Damé-Teixeire et al., 2013; Bücher, Neumann, Hickel, Künish, 2013; Andreasen, Andreasen, Andersson, 2007).

There are a number of factors involved in the origin of dental injuries. These include oral factors of the child, environmental factors and the child's mode of behaviour. Dental injuries occur most frequently in children with malocclusion, protrusion of the upper incisors and poor lip closure. Other predispositional oral factors include carious and hypoplastic changes of hard dental tissues, as well as oral piercing and various bad habits associated with abnormal use of the teeth (Glendor, 2008; Hecova et al., 2010). Significant predispositional factors in dental injuries are hyperactive children, behavioural problems and child obesity (Damé-Teixeire et al., 2013). Children from divorced, incomplete or foster families also suffer more from dental injuries (Damé-Teixeire et al., 2013).

Marcenes et al. (Marcenes, Zabot, Traebert, 2001) examined the influence of socio-economic factors on the occurrence of TDI and came to the surprising conclusion that there was a higher occurrence of trauma in children from higher socio-economic groups. They account for this difference by the fact that these children have easier access to various high-risk sports.

The aim of current questionnaire survey was to ascertain the occurrence of traumatic injuries, including injuries to teeth and jaw in children participating in sports at school and also competitively, and children participating in sports at school and in their free time only recreationally. A higher prevalence of traumatic injuries, including injuries to orofacial region was anticipated in children engaged in competitive sport. The second aim of the study was concentrated on use of sports mouthguards in children.

Material and methods

Ethical considerations

Ethical approval for the investigation was obtained from the Research Ethics Committee Faculty of Medicine in Pilsen, Charles University in Prague, Czech Republic.

Data collection method

In order to obtain data concerning the occurrence of injuries and the causes thereof, a questionnaire was designed, consisting of two parts. The first basic section of the questionnaire contained six questions for ascertaining the gender and age of the child, sports activities, means of protection used when doing sport and whether the child had suffered any injury, including an injury to the face, oral cavity and teeth. The second section contained five questions and concerned only those children who, in response to the question as to whether they had ever suffered an injury to their teeth or jaw, answered in the affirmative. The validity of the questionnaire for the purposes of current study was tested in 2011 on a group of 130 children whose average age was 14, within a project entitled "A safe environment for children without injuries from sport and other activities – with a focus on dental injuries" (Programme for the care of children and teenagers of the Ministry of Education of the Czech Republic).

As the target group for the questionnaire, children were chosen from the upper level of three primary schools with extended tuition in sport (Pilsen, Czech Republic). 400 questionnaires were delivered to 16 classes with an average of 25 pupils each. The questionnaires were sent to the parents of children via their teachers. The parents and their children completed the questionnaires together. The response rate was 80.3%. Thus 341 children from the upper level of two primary schools in Pilsen participated in the questionnaire survey. These children came from both similar socio-economic and cultural backgrounds, as well as from the same district of the city.

Data analysis

For evaluating most of the questions, basic descriptive statistics were used in Microsoft Office Excel. A comparison of the number of injuries in children involved in competitive sports and children not involved in competitive sports was conducted on the basis of the Pearson chi-square test for contingency tables. A statistical significance level of $p < 0.05$ was established. To this end the STATISTICA program from the StatSoft ČR firm was used.

Results

The questionnaire was completed by 341 pupils (175 girls and 166 boys) attending a primary school. The characteristics of respondents is mentioned in Table 1.

Table 1. Characteristics of respondents

Number of children	Gender		Average age	Number of competitive athletes	Number of non-competitive athletes
	girls	boys	13		
341	175 (51.3%)	166 (48.7%)	SD = 1.25	204 (59.8%)	137 (40.2%)

SD – standard deviation.

Source: qestionnaire survey.

The most common competitive sports amongst survey participants were soccer (58 pupils, or 28.4%), aerobics (27 pupils, or 13.2%), floorball (21 pupils, or 10.3%) and ice hockey (21 pupils, or 10.3%). 40 pupils (19.6%) practised two sports competitively.

An injury sustained during sport was mentioned by 193 pupils (56.6%); 144 pupils (42.8%) stated they had suffered no sporting injuries in the past; four pupils (1.2%) offered no response to this question.

232 children (68.0%) use some form of protection during sport. Approximately half this number practises sport competitively. The most common used means of protection are an ice – hockey helmet and a cyclist's helmet (174 pupils, or 51.0%). A sport-mouthguard is used only by ten pupils (eight boys and two girls), which is 2.9%.

Most often children injured themselves between the ages of six and 10 years: this age category accounted for 20 pupils (42.4%). 21 children (45.4%) did not respond to this question.

Out of the 341 respondents, 47 had suffered injuries to teeth or the jaw. An injury to a tooth or teeth was mentioned by 38 pupils of whom 21 were boys and 17 girls. Six pupils had had jaw injuries and three pupils (0.9%) injuries to the teeth and jaw (Table 2).

Table 2. Orofacial traumatic injuries in 341 respondents

Injury	Number of children
Dental injury	38 (11.1%)
Jaw injury	6 (1.8%)
Dental and jaw injury	3 (0.9%)
Total	47 (13.8%)

Source: qestionnaire survey.

The most common type of injury in 47 respondents was a clinical crown fracture (22 children, or 46.8%). An injury to the periodontal tissues was mentioned by 13 children (27.7%) and a combined injury to the periodontal tissues and hard dental tissue had been suffered by three pupils (6.4%).

Out of 47 (13.8%) pupils who answered they had suffered an injury to teeth or the jaw, 33 (70.2%) had sustained this injury while doing sport, most commonly soccer. The remaining 14 pupils (29.8%) stated they had sustained their injury at school, at home or at a children's playground.

Table 3. Injuries in 341 respondents

	Non-orofacial injuries		Orofacial injuries	
	competitive sport	non competitive sport	competitive sport	non competitive sport
Number of children	97 (66.4%)	49 (33.6%)	33 (70.2%)	14 (29.8%)
Total	146		47	
Chi square test	p = 0.07		p = 0.22	

Source: questionnaire survey.

97 of those doing competitive sport from an overall total of 146 had sustained various types of injuries except orofacial traumas. In the group of children not engaged in competitive sport, the number was 49. Using the chi-square test for contingency tables, the difference between the two groups of pupils was statistically non-significant

(p = 0.07). It can therefore be stated that there was no significant difference in the number of injured children between the two groups of pupils. It is, however, clear from the data that there is a slightly higher occurrence of injury among pupils who are involved in competitive sport than among those who are not (Table 3).

33 of those doing competitive sport had suffered orofacial injuries, compared to 14 pupils not engaged in competitive sport. A comparison of the two groups was similarly conducted using the chi-square test. Again injuries to teeth and jaw were slightly more common in pupils doing competitive sport. However, using a 5% significance level, there was no statistical difference between injuries to the teeth and jaw in both groups (p = 0.22) (Table 3).

Discussion

Injuries to the teeth occur in boys and girls in primary, mixed and permanent dentition. It has been established that 71–92% of dental injuries occur before the age of 19 (Davis, Scott, 1984). Gassner et al. (Gassner, Bosch, Tuli, Emshoff, 1999) reached the conclusion that almost 50% of dental injuries occur before the age of 10, at a time when neither teeth nor jaw are fully developed. The period of highest risk in terms of injury to teeth and jaw is at the age of 9–10 years (Andreasen, Ravn, 1972). In present sample the injuries occurred most commonly during this high risk period. The same conclusion was reached by Atabek et al. (2013). The prevalence of injuries to permanent teeth in 12-year-old boys is given as 12–33% and in girls 4–19% (Andreasen, Ravn, 1972). Considerable differences in the occurrence of dental injuries in various epidemiological studies are probably caused by the various methods of raising children, cultural and social norms and ways of spending free time, as well as socio-economic factors, non-uniform methodology and differing diagnostic criteria. In current sample of schoolchildren, whose average age was 13, injuries to the jaw and teeth occurred in 13.8% of those surveyed. 11.1% of children had injured only their teeth. The majority of authors (Glendor, 2008; Andreasen et al., 2007) record a significantly higher occurrence of injury in boys than in girls. In boys the prevalence of injury to permanent teeth is even twice as frequent as in girls. This difference is explained by the more risky behaviour of boys by engaging in contact sports and sports with a greater risk of teeth injuries. A difference between males and females in the occurrence of teeth injuries is also evident in university students. Biazevic et al. (2010) ascertained that the risk of dental injury is 2.78 greater for male students than females. Some studies (Skaare, Jacobsen, 2003; Rocha, Cardoso, 2001), however, indicate a reduction in the difference between boys and girls in injuries to permanent teeth: this is due to a change in the behaviour of girls, who are now beginning to engage in contact sports or high-risk sports which were previously the sole prerogative of boys and which carry a high risk of dental injury. Likewise in current study there was no pronounced difference between boys and girls in the occurrence of dental injuries. The ratio of boys to girls was 1.25 : 1. As in a series of other studies (Andersson, 2013; Hecova, 2010; Taiwo, Jalo, 2011) current questionnaire also showed the most frequent type of injury was the fracture of a clinical crown, which occurred in 46.8% cases of children with injuries to permanent teeth.

The Fédération dentaire international (FDI) divides sports according to the risk of dental injuries into high-risk and medium-risk (Federation Dentaire International, 1990). High-risk sports include American football, ice hockey, field hockey, lacrosse, martial arts, rugby, inline skating, skateboarding and mountain bike riding. Medium-risk sports include basketball, soccer, handball, diving, squash, gymnastics, parachuting and water polo. The majority of risky sports consists of so-called contact sports, in which participants come into either direct contact (boxing, martial arts, judo) or indirect contact (handball, basketball, soccer, ice hockey). The school pupils in current sample who participated in medium-risk competitive sports were most often involved in soccer and floorball, and of the

high-risk sports ice hockey. The risk of dental injuries during sporting activities should not be underestimated. It is stated that during their sporting careers 50% of sportsmen and -women will suffer a TDI (Heintz, 1968). In every season, every participant in a contact sport has a 10% risk of a TDI (Schulze, 2008). Dental injuries occur most often during sporting encounters (69%), while the remaining 31% are incurred during training: this is probably due to the fact that participants risk more in a proper competitive encounter (Sane, Ylipaavalniemi, 1988). Some authors (Lang et al., 2002; Ozbay et al., 2013) have studied the occurrence of dental injuries in participants of indirect contact sports such as handball and basketball. Ozbay et al. (2013) have found a 19.34% dental injury rate in handball players. The medical records of 16.6% of basketball players whose average age was 22.28 years mention dental injuries sustained during a game (Perunski et al., 2005). In present data 13.8% of pupils had sustained an injury to teeth or jaw during sport. The highest risk sport in the current sample was soccer.

The best prevention of all injuries is better information on dental injuries, the avoidance of such injuries, provision of first aid on the spot and the necessity of timely treatment. Education should be aimed not only at children and their parents but also at teachers, tutors and trainers. Dental injuries sustained during sport are foreseeable and can thus be avoided by means of a mouthguard. A significant reduction in the risk of dental injuries during sport by using a mouthguard has been demonstrated through research (Lang, Pohl, Filippi, 2002; Perunski, Lang, Pohl, Filippi, 2005). Sports mouthguards can either completely prevent or significantly reduce injuries to lips and teeth (Davis, Scott, 1984). The use of mouthguards by children and young people varies in different sports: in some sports, along with other protective elements, they form part of the participant's basic equipment. If a mouthguard is not compulsory according to the rules of the given sport, its voluntary use amongst children and young people is not especially common. Research by Rodd and Chesham (Rodd, Chesham, 1997) showed that in the 14–15 age group only 6% of youngsters use a mouthguard during sport; that number was significantly lower amongst girls and children from lower socio-economic groups. Present research came to the same conclusion with regard to the use of mouthguards amongst girls and boys. One interesting fact concerning children and mouthguards was ascertained by Fakhruddin et al. (Fakhruddin, Lawrence, Kenny, Locker, 2007), who state that only 5.5% of children use a mouthguard during sporting activities at school. A significantly higher number (20.2%) use a mouthguard when practising competitive sport. Similarly mouthguards are used more often by participants in sport at university (19.24%) (Skaare, Jacobsen, 2003). Only 2.9% of children in current survey stated they use sports mouthguards. Basketball players with an average age of 22.28 years use mouthguards even less: in a questionnaire survey only 1.4% stated they use a mouthguard regularly during play (Perunski et al., 2005). The reasons for not wearing a mouthguard vary: a number of youngsters do not believe in the effectiveness of mouthguards or consider them too expensive, unaesthetic and likely to cause problems with breathing and speech. Many adolescents do not use a mouthguard because they were not advised to do so, by neither parents nor trainers. Custom-made mouthguards, professionally prepared on the basis of a dental impression, were possessed mostly by children who regularly visited the family dentist (Fakhruddin et al., 2007).

In addition, youngsters engaging in sport often sustained injuries to the soft tissue of the oral cavity and jaw, the most common being bruising and lacerations to the lips and oral mucosa. Injuries to the jaw are less frequent. Only 1.8% of the children in present survey mentioned separate jaw injuries, and 0.8% combined injuries to teeth and jaw. Likewise Gassner et al. (Gassner, Tuli, Hächl, Moreika, Ulmer, 2004) mention a greater risk of dental injury while doing sports than maxillofacial injuries.

Current study compared the prevalence of injuries in the orofacial area in children involved in competitive sports and children doing sport only at school or recreationally. It was supposed a higher prevalence of injuries in children who were active in competitive sports since in their case there would be greater possibilities of injury not only during training but also in competition. Children involved in competitive sport did indeed display a higher incidence of injury; however, the difference between the two groups of youngsters was not statistically significant. This was probably due to the fact that the youngsters surveyed were attending schools with extended sports activities and significant differences between the two groups were thus eliminated. Research studies dealing with a similar topic are rare. One example concerned university students and here the authors (Biazevic et al., 2010) concluded that those participating in sport had a 3.45-times greater chance of dental injury than those students who did not.

In addition to injuries to teeth, oral cavity, jaw and the head, children doing sport may also sustain a whole series of injuries to fingers, elbows and ankles, including fractures of the upper and lower limbs. Williams et al. (1998) recorded the incidence of injuries in children practising sport on a regular basis and children doing so only occasionally in their free time. This research showed 32.2% of children had suffered injuries during sport. In present questionnaire study 42.8% of children mentioned having sustained an injury during sport. However, a significant statistical difference between the cohort of children engaged in competitive sport and those doing sport only in school lessons and recreationally was not ascertained.

Conclusion

Sport-related injuries, including dental traumas, are a hazard not only for children engaged in competitive sport but also in children performing sport only at school and recreationally in their free time. The occurrence of TDI was higher but not statistically significant among pupils who are involved in competitive sports. No significant difference between girls and boys was found in current study. The most of children sustained orofacial injuries during trainings and competitions. Sport-related injuries differ from other types of injury in that they are foreseeable and can be avoided by appropriate protection. Current questionnaire revealed that the use of sports mouthguards by children doing competitive sport is minimal.

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LONG-TERM CHANGES IN BODY BUILD OF MALE AND FEMALE JUDO COMPETITORS

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Abstract The aim of the study was to determine if changes in the body build of judo athletes over a time span of 20 years are in line with trends described in the literature. Anthropometry of 60 male and 46 female judokas was performed. Data was collected from two cohorts: the first involved 30 males and 23 females measured in 1994–1995 and the second 30 males and 23 females in 2013. Anthropometric profiles included measurements of skinfolds, height, weight, and body and segment lengths, breadths, and girths. Although relatively identical heights and weights were found between the cohorts, significant differences were detected for body proportion measures. Males in 1994–1995 showed a significantly longer trunk, wider shoulders and hips, and more subcutaneous adipose tissue than the 2013 cohort. Females in 1994–1995 showed a shorter trunk, larger diameters of the trunk in relation to body height, and significantly lower skinfold thicknesses than the 2013 cohort. The direction of changes in the physical characteristics of judokas should be taken into consideration by coaches during training. Combat techniques should be adapted to the morphological traits of the athletes to achieve success and minimize the risk of overloading or injury.

Key words secular trend, judo, body proportion

Introduction

Secular changes in human beings are indicative of how the body develops in light of genetic determinants (Tanner, 1992; Bielicki, Szklarska, 1999). According to Henneberg (2001), these changes are the result of factors that affect gene expression responsible for growth. Significant factors include healthcare, diet, the state of livestock farming and agriculture, all of which may stimulate the endocrine system to secrete growth hormones. The literature most commonly indicate secular trends in increased body height and reduced age of sexual maturation (Roche, 1979; Tanner, 1987; Malina, 1990; Hauspie, Vercauteren, Susanne, 1997; Bielicki, Szklarska, 1999; Cole, 2000).

However, change in the relationship between body height and weight was found to vary in different ways depending on socioeconomic criteria. Some studies have found a plateauing or even reversal of such secular changes in certain populations, mostly among those with relatively stable, high-level living conditions (Brundtland, Walloe, 1973; Cernerud, Lindgren, 1991).

The findings of many studies have also indicated intergenerational changes in body composition, subcutaneous fat levels, body proportions, and somatotype (Piechaczek, Lewandowski, Orlicz, 1996; Hughes, Li, Chinn, Rona, 1997; Ziółkowska-Łajp,1999; Stachoń, Burdukiewicz, Pietraszewska, Andrzejewska, 2012; Saczuk, Wasiluk, Wilczewski, Wilczewski, 2016). In Poland, a number of studies identifying secular trends in body build have focused on populations of university students representing academic disciplines (Milicer, Skibińska, Skład, 1974; Pilicz, 1979; Piechaczek, Łaska-Mierzejewska, Skibińska, 1986; Pilicz, 1998; Sitek, Szkudlarek, Antoszewski, 2007; Mleczko, Januszewski, 2009; Stachoń et al., 2012). Differences in the level of changes have been identified between males and females, what can be conditioned by varied susceptibility to environmental stimuli (Bielicki, Charzewski, 1977; Chlebicka, 1988).

While the above studies have examined untrained populations, there is not much research of study on identifying secular trends among athletes. Sedeaud et al. (2014) showed, that between 1871 and 2011, athletes from the four sports have increased significantly in mass, height and BMI. Research by Malina, Figueiredo, Coelho-e-Silva (2017) indicates, that the body size of youth soccer players increased between 1978–1999 and 2000–2015. Norton, Olds (2001) report, that athletes in many sports have been getting taller and more massive over time; the rates of rise outstripping those of the secular trend. Some sports demand a narrow range of morphological characteristics. In these sports the size of the most successful athletes has remained constant, despite the secular trend in the population non-athletes. Each sport demands a particular set of attributes, including body composition and proportions. This issue is of importance in light of the association between structural body dimensions and functional performance. Such trend analysis may contribute to current assessments of the body's response to exercise and also aid athletes. In certain athletic disciplines, talent identification and athlete selection is also based on an anthropometric profile that may need to be modified due to changes in the physical characteristics of successive generations of athletes. Furthermore, developments in specialized training programs should take changes in body build in order to minimize injury via overloading.

The purpose of the present study was to examine the changes in the body build of judo athletes and, if present, determine whether they were in line with the trends observed in recent decades in untrained groups and other sport disciplines. In order to achieve that purpose, the following research questions were posed:

- Is the course of secular changes the same in judokas of both sexes?
- Which features of the somatic build exhibit the most significant changes?
- Are secular changes in judokas the same as in other populations?

The study also considered whether changes in body build may have had an effect on muscle strength.

Material and methods

Participants

The study used a data set of anthropometric measures on 60 male and 46 female judo practitioners from university-level sports clubs. They represented regional and national level. Data of the first group (30 men and 23 females) was collected in 1994–1995, whereas for the remaining 30 males and 23 females in 2013.

The average age of male subjects in the first group was 21.5 ±2.7 years, while in the second group it was 22.4 ±2.9 years. In the group of female subjects examined in 1994–1995 the average age was 21.7 ±2.4 years, while in the second group – 21.9 ±2.6 years. The overall length of time that the male and female athletes had spent practising their discipline was 7–16 years.

The male subjects represented weight categories from 66 to 90 kg and the female subjects – from 52 to 78 kg. In the cohorts examined in 1994–1995 and in 2013 the share of the representatives of each weight category was the same.

Measurements

Measurements were administered according to International Standards for Anthropometric Assessment (ISAK) (Norton, Olds, 2002). They were supplemented by a few measurements. Anthropometric measures selected for analysis included: body height (B-v), trunk length (sst-sy), upper limb length (a-da3), lower limb length (B-tro), biacromial diameter (a-a), chest diameter (thl-thl), chest depth (xi-ths), biiliocristal diameter (ic-ic), elbow breadth (cl-cm), knee breath (epl-epm), shoulder circumference, chest circumference at rest and at peak inhalation and exhalation, waist circumference, arm circumference at rest and flexed, hip circumference, and maximal circumferences of the forearm, thigh, and calf. A Harpenden body fat caliper was used to obtain skinfold measurements at the subscapular, triceps, forearm, suprailiac, abdominal, and medial calf regions. The measurements were made by the same people. Body height, lengths and breadths were measured to the nearest 0.1cm with the use of a GPM Anthropological Instruments (SiberHegner Machinery Ltd., UK). Skinfold thickness was measured with a Tanner/Whitehouse skinfold calliper (Holtain, UK) with 0.2 mm graduation. Body mass was measured with an electronic weighing scale with an accuracy of 0.1 kg. Somatotype was classified according to Sheldon's method as modified by Heath and Carter to determine the levels of endomorphy, mesomorphy, and ectomorphy in the cohorts (Carter, Heath, 1990). Body proportions were calculated based on the following ratios: trunk length/body height, biiliocristal diameter/biacromial diameter, biacromial diameter/body height, biiliocristal diameter/body height, chest circumference at rest/body height, chest depth/chest diameter, waist circumference/hip circumference (WHR), and BMI. Muscle strength was assessed with a Takei handgrip dynamometer. The handgrip was adjustable and measured force from 0 to 100 kgf with an accuracy of 0.5 kgf.

Statistical analysis

Basic statistical methods included the Kolmogorov-Smirnov test to determine the normality of the data, finding it did not significantly deviate from a normal distribution. On this basis, all subsequent statistical methods assumed a normal distribution. Intergroup differences were assessed using Student's t test. The strength of associations between handgrip strength and the anthropometric measures were determined by the Pearson product-moment correlation coefficient. The results obtained were analysed with the use of basic statistical methods (Statistica 12.0).

Ethical approval

Ethical approval for the project was obtained from the Ethical Committee at the University School of Physical Education in Wrocław (Ethical clearance 23.10.12). Their ethical guidelines were honoured throughout the study. Participants provided oral informed consent prior to testing.

Results

No differences in body height were found between the male and female judokas from the two cohorts (Table 1). The male judokas in 1994–1995 had a significantly longer torso and wider shoulders and hips than the 2013 cohort. Among the circumference measures, significant differences were observed for arm circumference (Table 2). The 2013 male cohort had approximately 1.5 cm larger arm circumferences at rest and when flexed. Among the females, no statistically significant differences were noted except for shoulder circumference. The 2013 female cohort were measured with more than 4 cm smaller shoulder circumferences than their peers from 1994–1995.

Table 1. Statistical characteristics of body height, body mass, length and width of the examined competitors (mean ± sd)

	Males		Females	
	1994	2013	1994	2013
B-v (cm)	176.8 ±4.09	176.4 ±6.18	166.4 ±6.74	166.6 ±6.33
Body mass (kg)	76.1 ±4.48	77.6 ±4.62	63.7 ±7.34	65.8 ±8.85
sst-sy (cm)	52.3 ±2.72*	50.7 ±2.13*	46.4 ±3.45	47.8 ±3.42
a-da3 (cm)	77.0 ±2.49	77.7 ±3.07	72.0 ±2.98	72.6 ±2.42
B-tro (cm)	93.4 ±3.29	93.8 ±2.87	88.7 ±3.49	87.7 ±4.32
a-a (cm)	44.5 ±3.12*	43.1 ±1.64*	38.2 ±2.75	37.0 ±2.05
thl-thl (cm)	30.6 ±2.67	30.4 ±1.49	26.4 ±1.64	26.3 ±1.67
xi-ths (cm)	20.6 ±1.36	20.4 ±1.85	18.4 ±1.37	18.8 ±1.48
ic-ic (cm)	29.6 ±2.47*	28.3 ±1.19*	28.9 ±2.11	27.8 ±2.27
cl-cm (cm)	7.2 ±0.30	7.2 ±0.26	6.3 ±0.35	6.3 ±0.35
epl-epm (cm)	10.1 ±0.42	10.2 ±0.37	9.4 ±0.53	9.4 ±0.60

B-v (body height), sst-sy (trunk length), a-da3 (upper limb length), B-tro (lower limb length), a-a (biacromial diameter), thl-thl (chest diameter), xi-ths (chest depth), ic-ic (biiliocristal diameter), cl-cm (elbow breadth), epl-epm (knee breath).

* Significant differences between groups (1994 and 2013) ($p \leq 0.05$).

Table 2. Statistical characteristics of circumference of the examined competitors (mean ± sd)

	Males		Females	
	1994	2013	1994	2013
Shoulder circumference (cm)	118.6 ±4.10	118.7 ±4.23	110.2 ±6.61*	105.8 ±6.24*
Chest circumference at rest (cm)	100.6 ±5.10	99.9 ±4.69	91.0 ±5.07	90.8 ±4.13
Chest circ. at peak inhalation (cm)	105.2 ±4.76	104.1 ±4.38	96.1 ±5.02	95.2 ±4.55
Chest circ. at peak exhalation (cm)	97.1 ±4.16	97.3 ±5.03	88.8 ±5.52	88.0 ±4.70
Waist circumference (cm)	78.5 ±3.98	80.2 ±4.26	72.4 ±5.54	74.5 ±5.60
Arm circumference (rest) (cm)	31.4 ±2.12*	33.0 ±1.99*	27.9 ±2.46	28.8 ±2.50
Arm circumference (flexed) (cm)	34.9 ±1.98*	36.5 ±2.21*	30.5 ±2.33	31.0 ±2.23
Forearm circumferences (max) (cm)	28.3 ±1.44	28.5 ±1.48	25.3 ±1.55	25.0 ±1.36
Hip circumference (cm)	97.4 ±3.76	96.4 ±4.11	98.3 ±6.14	100.4 ±7.10
Thigh circumference (cm)	57.4 ±2.35	57.7 ±2.91	58.3 ±4.71	58.5 ±4.72
Calf circumference (cm)	37.1 ±1.68*	38.1 ±2.00*	36.6 ±3.15	36.8 ±2.59

* Significant differences between groups (1994 and 2013) ($p \leq 0.05$) .

Larger values of subcutaneous adipose tissue was found among the male cohorts from 1994–1995 than those in 2013. Although almost all skinfold values were larger, only triceps skinfold thickness was statistically significant (Table 3).

Table 3. Statistical characteristics of skinfolds and body build components of the examined competitors (mean ± sd)

	Males		Females	
	1994	2013	1994	2013
Subscapular skinfold (mm)	8.8 ±2.70	8.7 ±1.71	10.3 ±3.23	11.9 ±3.54
Triceps skinfold (mm)	5.6 ±2.28*	4.4 ±1.65*	4.0 ±1.54*	11.0 ±2.85*
Forearm skinfold (mm)	3.3 ±0.93	2.9 ±0.64	2.8 ±0.60*	4.0 ±1.04*
Suprailiac skinfold (mm)	8.2 ±3.44	6.6 ±2.45	7.6 ±3.18*	12.4 ±4.22*
Abdominal skinfold (mm)	6.9 ±2.39	8.4 ±3.54	9.8 ±4.60*	13.8 ±3.73*
Calf skinfold (mm)	4.3 ±1.07	4.4 ±0.82	3.2 ±0.95*	7.5 ±2.24*
Endomorphy	2.2 ±0.71*	1.8 ±0.59*	2.1 ±0.77*	3.6 ±0.85*
Mesomorphy	6.0 ±0.84*	6.6 ±1.04*	5.2 ±1.41	5.1 ±0.99
Ectomorphy	2.0 ±0.66	1.7 ±0.80	1.8 ±1.09	4.0 ±0.94

* Significant differences between groups (1994 and 2013) ($p \leq 0.05$).

Consequently, this finding was congruent with the significantly larger proportion of endomorphy and lower share of mesomorphy in the 1994–1995 cohorts. Opposite results were found in the group of female judokas. The 2013 females showed increased skinfold thickness compared with the 1994–1995 cohort. With the exception of the subscapular skinfold, the remaining skinfold measures were significantly different between the two cohorts, the effect of which accounted for the higher level of endomorphy in the 2013 females.

When comparing body proportions, a number of significant differences were also observed (Table 4). The 1994–1995 male cohort exhibited greater biacromial and biiliocristal diameters in relation to body height than their peers from 2013. In addition, they showed a relatively longer trunk and lower waist circumference/hip circumference ratio. Similar among the females, the 1994–1995 cohort had larger biacromial and biiliocristal

Table 4. Statistical characteristics of the proportion indexes of the examined competitors (mean ± sd)

	Males		Females	
	1994	2013	1994	2013
(sst-sy / B-v) × 100	29.6 ±1.18*	28.7 ±0.55*	27.8 ±1.40*	28.7 ±1.68*
(sst-sy / B-tro) × 100	56.0 ±2.28*	54.14 ±1.59*	52.3 ±3.62*	54.7 ±4.64*
(ic-ic / a-a) × 100	66.7 ±5.67	65.7 ±3.33	75.8 ±4.48	75.3 ±5.12
(a-a / B-v) × 100	25.2 ±1.66*	24.4 ±0.85*	23.0 ±1.64*	22.2 ±0.86*
(ic-ic / B-v) × 100	16.8 ±1.36*	16.0 ±0.73*	17.4 ±1.13*	16.7 ±1.25*
(chest circumference / B-v) × 100	56.9 ±2.99	56.7 ±2.29	54.7 ±3.34	54.5 ±2.67
(waist circumference / hip circumference) × 100	80.7 ±3.61*	83.2 ±2.55*	73.7 ±3.98	74.3 ±5.31
(xi-ths/ thl-thl) × 100	67.6 ±6.48	67.1 ±5.59	69.8 ±5.30	71.4 ±4.39
BMI	24.3 ±1.41	25.0 ±1.58	23.0 ±2.35	23.7 ±2.45

B-v (body height), sst-sy (trunk length), B-tro (lower limb length), a-a (biacromial diameter), thl-thl (chest diameter), xi-ths (chest depth), ic-ic (biiliocristal diameter).

* Significant differences between groups (1994 and 2013) ($p \leq 0.05$).

diameters in relation to body height than the 2013 cohort. A different direction was observed in terms of female trunk length. Judokas in 2013 exhibited a longer trunk in relation to body height and lower limb length than the 1994–1995 cohort.

Table 5. Correlation of the handgrip strength with the morphological features of the examined competitors (Pearson's r)

	Males	Females		Males	Females
Body mass (kg)	0.45	0.39	Waist circumference (cm)	0.19	0.12
B-v (cm)	0.28	0.37	Arm circumference (rest) (cm)	0.30	0.14
sst-sy (cm)	0.25	0.27	Arm circumference (flexed) (cm)	0.42	0.11
B-tro (cm)	0.27	0.20	Forearm circumferences (cm)	0.69	0.26
a-a (cm)	0.20	0.31	Hip circumference (cm)	–0.06	0.27
thl-thl (cm)	–0.04	0.16	Thigh circumference (cm)	0.21	0.07
xi-ths (cm)	0.13	0.02	Calf circumference (cm)	0.47	0.30
ic-ic (cm)	0.02	0.12	Subscapular skinfold (mm)	–0.31	0.09
cl-cm (cm)	0.52	0.23	Triceps skinfold (mm)	–0.21	0.08
epl-epm (cm)	0.12	0.29	Suprailiac skinfold (mm)	–0.20	0.11
Shoulder circumference (cm)	0.33	0.28	Abdominal skinfold (mm)	–0.10	–0.03
Chest circumference (cm)	0.23	0.33	Calf skinfold (mm)	–0.18	–0.22

B-v (body height), sst-sy (trunk length), B-tro (lower limb length), a-a (biacromial diameter), thl-thl (chest diameter), xi-ths (chest depth), ic-ic (biiliocristal diameter), cl-cm (elbow breadth), epl-epm (knee breath).

The search for associations between handgrip strength and the anthropometric measures indicated that the strongest correlation among males was between handgrip strength and body weight, circumferences of the forearm and arm, and humerus breadth (Table 5). Among females, the strongest relationship was between handgrip strength and body weight, body height, chest circumference, and biacromial diameter.

Discussion

When analyzing for trends in body build, the majority of the literature indicates increased body height in successive generations of Polish males and females (Milicer et al. 1974; Hughes et al. 1997; Pilicz, 1998; Sitek et al. 2007; Mleczko, Januszewski, 2009; Stachoń et al. 2012). This finding was not confirmed in the samples of male and female judo practitioners from 1994–1995 and 2013, although this may have been the effect of sampling athletes from the same weight categories.

In other populations, Tanner, Hayashi, Preece, Cameron (1982) indicated a secular trend in body height due to changes in lower limb length resulting in differences in trunk /leg proportions. Compared with the present study, a similar result was found among the males in which the 2013 cohort exhibited significantly reduced trunk length in relation to body height and also to lower limb length. This is unfavorable for judokas, because the center of gravity is higher. Among females, a significant increase in the length of the trunk was found among the 2013 cohort. Various authors have suggested that the physical traits of a martial artist could be used to determine the most optimal fighting technique (Sterkowicz-Przybycień, 2010). A similar conclusion was reached by Lech, Sterkowicz, Rukasz (2007), who found that taller and thinner individuals were more likely to use leg techniques, while those larger and shorter more commonly used hand techniques. Differences were also found in the effectiveness of blocking

depending on body height. The results of the present study indicate the validity of analyzing fighting techniques in martial arts by controlling for the physical traits of martial artists.

The literature on the Polish population describes a slimmer body profile in successive generations of young adult males (Piechaczek et al. 1996; Milicer et al. 1974; Pilicz, 1998; Mleczko, Januszewski, 2009). While the results of the present study did indicate a decrease in skeletal size (biacromial and bicristal diameters), the body profile of the males became more massive due to increased muscle mass. This was indicated by the significantly larger arm circumferences and larger waist circumference/hip circumference ratio. A significant increase of mesomorphy was also found in the 2013 cohort, in which a trend of decreased skinfold thickness and, consequently, decreased level of endomorphy can be seen. A similar trend in the level of mesomorphy was observed by Stachoń et al. (2012) among males attending a physical education university. However, none of the cited studies found any significant changes in the level of endomorphy. Low body fat content is known to assist fighting performance as well as improve blocking reaction speed, qualities that are very important in combat sports (Pieter, Bercades, Kim, 2006). Therefore, the observed differences between the generations of judokas may be indicative of suitable training methods.

Among the female judokas, a trend similar to the males was observed in the diameters of the torso. The 2013 cohort exhibited smaller shoulder and hip diameters than those from 1994–1995. While no significant changes in musculature and BMI were noted, a marked increase in skinfold thicknesses can be observed, which resulted in a significantly greater level of endomorphy. A similar trend was observed in Polish physical university students by Stachoń et al. (2012).

Research conducted on different populations has found that the trend for increased stature and earlier development did not translate into improved motor skills (Roche, 1979; Pilicz 1998; Mleczko, Januszewski, 2009; Przewęda, Dobosz, 2003; Przewęda, 2009; Drozdowski, Ziółkowska-Łajp, 2012). Due to a lack of data, long-term changes in the level of motor performance was not analyzed in the present study. However, we did search for relationships between handgrip strength and the anthropometric measures in the 2013 cohort.

Studies have shown that in judo a competitor holds an opponent by judogi (clothing) for a long time. A substantial handgrip strength is crucial in fight circumstances (Marcon, Franchini, Jardim, Neto, 2010; Vidal Andreato et al., 2011). The findings indicate that handgrip strength in males most strongly correlated with body weight and limb circumference. The observed trend of increasing limb circumference when comparing the 2013 and 1994–1995 cohorts allows for the conclusion that the strength ability of judo practitioners has increased compared with the previous generation of judokas. Other studies have confirmed the relationship between strength and the cross-sectional area of muscle (Maughan, Watson, Weir, 1983). The correlation coefficients were lower in females, with the strongest relationship between handgrip strength and the upper torso measures. This result supports the conclusion that handgrip strength in female judokas from 2013 is not directly related with changes in their body size and shape.

Conclusions and Practical application

Secular changes in body build and proportions among male and female judo practitioners were not always congruent with the trends described in the literature among various populations. This indicates the need to monitor the direction of changes separately for athletes of various disciplines. The results obtained in the study with regard to the tendency for female athletes to have more body fat should prompt trainers to modify the training regimen for women accordingly. Changes in the body proportions of judokas should be taken into consideration by coaches

during training. Combat techniques should be adapted to the morphological traits of the athletes to achieve success and minimize the risk of overloading or injury.

Conflict of interest

The authors state no conflict of interest.

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SCHOOL ENVIRONMENT VERSUS HOME ENVIRONMENT – COMPARISON OF SELECTED PARAMETERS OF CHILDREN PHYSICAL ACTIVITY

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Abstract In recent years research have shown a significant decrease in physical activity (PA) among young population. Increasingly carried out diagnosis of physical activity at different stages of our lives, with particular regard to children and adolescents indicates that with age, level of physical activity, especially in leisure time is reduced. The purpose of the research is to compare the selected parameters of physical activity during one day among students aged 6–8 years old. The study was conducted with use of the accelerometer ActiGraph WGT3X on group of 54 children (30 – school and 24 – kindergarten). Analysis shows that for such parameters as MET's, Vigorous, Total MVPA and Steps Counts one observed difference between the stay at school and sometimes school has statistical significance ($p < 0.05$).
On the basis of the studies carried out it is shown that the school environment helps to increase physical activity among children in school and the fact is that these children are more active.

Key words physical activity, accelerometer, school, kindergarten, WGT3X

Introduction

Previous studies show that among young people a significant decrease in physical activity is noted (PA) (Dumith, Gigante, Domingues, Kohl, 2011). Physical activity tends downward according to age throughout childhood and adolescence (Corder, Oglivie, Van Sluis, 2009, Dumith et al., 2011). Moreover, inactive children may become inactive adults, which in turn causes the higher risk of health complications in future life. Growing evidence of the health benefits of PA (Guinhouya, Samouda, Zitouni, Vilhelm, Hubert, 2011) have resulted in a growing need to understand the behaviour of PA and its patterns among children and adolescents. Previous cross – sectional studies among children and adolescents in physical activity, time spent in school and out of school have been carried out, among others, by such authors as: (Cox, Schofield, Greasley, Kolt, 2006; Tudor-Locke, Lee, Morgan, Beighle, Pangrazi, 2006). In many countries, increasingly guided diagnosis of physical activity at different stages of

life is promoted with particular emphasis on children and adolescents. It shows that according to age, the level of physical activity, especially during leisure time decreases (Brettschneider, Naul, 2004).

The creation of habit in physical activity should be already started at kindergartens and primary schools and physical education should be focused on the support of physical development. In addition, physical education plays an important role in meeting the needs of pupils from their early childhood and prepares them for the life in a society.

In the entire range of physical education an important role is fulfilled by the movement habits which have long-term impact on the human health and they should be shaped during the early development of children. That is why it is crucial to educate children in terms of the importance of health and leisure activities from their early childhood. If children are exposed to the adverse health risks at an early age, they have the tendency to maintain this type of behaviour during their puberty and adulthood, eventually leading to an increased risk of many chronic diseases.

Physical activity of children in Poland against the background of European children is at an average level and should be raised.

Material and methods

The purpose of the research is comparison and diagnosis of selected parameters of physical activity during the day amongst children at the age of 6–8 years with the use of accelerometer WGT3X. The day was divided into two segments of time: time spent at school (from 8 am to 2 pm) and time spent in the house (from 2 pm to 8 pm). On the base of the literature review research questions were constructed.

1. Is there a difference in physical activity (selected parameters) between pupils from school and from kindergarten?
2. Which part of the day (school and kindergarten and time spent outside of the facility) is more active?

Research diagnosis in physical activity of students aged 6-8 years was carried out in the selected school (30 children) and in the kindergarten (24) in Rzeszów (southern Poland) in 2016 (26 girls and 28 boys). As a basis for determining the groups there was adopted a regular and active participation in school activities (mainly with physical education or elements of rhythm, gymnastics in kindergarten), observations and opinions of teachers. The research has been carried out on Mondays and Wednesdays, so that they were as similar as possible to each other in terms of the number of hours spent at school and the type of activities. Measurement was performed once.

The measurement was made by the author, then it was analysed with the use of the specialized software Actilife (Actigraph).

For research the diagnostic device Accelerometer WGT3X-BT ActiGraph (WGT3X, Pensacola, 2014) was used. The use of accelerometer devices is a valuable supplement to the survey methods in study concerning level of physical activity (Herbert, Czarny, 2013). The analysed parameters: sedentary, light, moderate, vigorous physical activity and steps count.

Statistical methods

The analysed parameters (variables) were presented using basic statistical measures: mean and standard deviation. In order to verify the statistical significance of differences between the two medium-sized, test of order pairs of Wilcoxon was used.

Research results

Table 1. The results of physical activity parameters in kindergarten

Variables		$\bar{x}$	x_{min}	x_{max}	sd	V	d	p
Sedentary	school	35.1	19.7	51.5	6.9	19.6	–1.8	0.057
	home	36.9	14.3	56.3	9.6	26.0		
Light	school	18.7	7.2	31.5	4.7	25.3	1.6	0.008*
	home	17.1	2.7	34.8	5.9	34.6		
Moderate	school	5.2	0.3	16.7	3.0	57.6	0.1	0.388
	home	5.0	0.2	18.8	4.1	80.6		
Vigorous	school	1.0	0.0	6.0	1.1	106.0	0.1	0.197
	home	1.0	0.0	9.7	1.4	145.8		
Steps Counts	school	885.1	223.0	2561.0	470.5	53.2	27.6	0.182
	home	857.5	62.0	2908.0	656.4	76.6		

* Statistical significance (α = 0.05).
Shortcuts: x – average, x_{min} – minimum value, x_{max} – maximum value, sd – standard deviation, V – coefficient of variation, d – difference between home and school, p – probability test.

Source: authors' elaboration.

Table 2. The results of physical activity parameters at school

Variables		$\bar{x}$	x_{min}	x_{max}	sd	V	d	p
Sedentary	school	35.1	19.7	51.5	6.9	19.6	–1.8	0.057
	home	36.9	14.3	56.3	9.6	26.0		
Light	school	18.7	7.2	31.5	4.7	25.3	1.6	0.008*
	home	17.1	2.7	34.8	5.9	34.6		
Moderate	school	5.2	0.3	16.7	3.0	57.6	0.1	0.388
	home	5.0	0.2	18.8	4.1	80.6		
Vigorous	school	1.0	0.0	6.0	1.1	106.0	0.1	0.197
	home	1.0	0.0	9.7	1.4	145.8		
Steps Counts	school	885.1	223.0	2561.0	470.5	53.2	27.6	0.182
	home	857.5	62.0	2908.0	656.4	76.6		

* – statistical significance (α = 0.05).
Shortcuts: x – average, x_{min} – minimum value, x_{max} – maximum value, sd – standard deviation, V – coefficient of variation, d – difference between home and school, p – probability test.

Source: authors' elaboration.

In the analysis of typically sedentary activities in kindergarten (intensity of not more than 2 METs) it is noted that the highest levels of this variable is recorded at the end of the day in home (between 5 pm–7 pm), the total of 60% of the time during the entire test. In turn, at school the highest levels of this variable is at the beginning of the day (between 8:00 am–10:30 am) and the total of 54% of the time during the entire test.

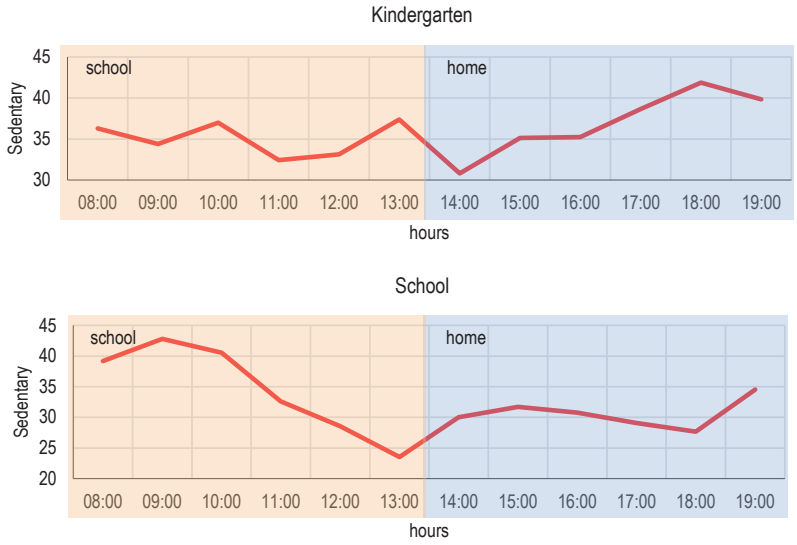

Figure 1. Sedentary behaviour of children during education time and in the house between 8 am–8 pm

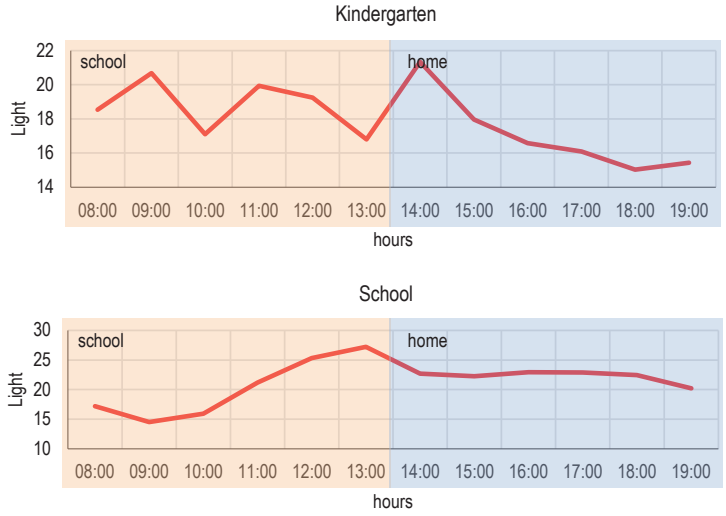

Figure 2. Light behaviour of children during education time and in the house between 8 am–8 pm

The course of the average value of light efforts (intensity range from 3 to 6 METs) indicates that throughout the duration of stay in kindergarten, this parameter has some fluctuations and is maintained at higher altitude in relation to the hours of the afternoon. It gives us approximately 30% of the time that was spent in this way. The school has

a slightly opposite tendency where this parameter remains at a lower level during the school education to achieve its peak about 1 pm and so remains until the end of the test. It gives us nearly 35% of the time that was spent in this way.

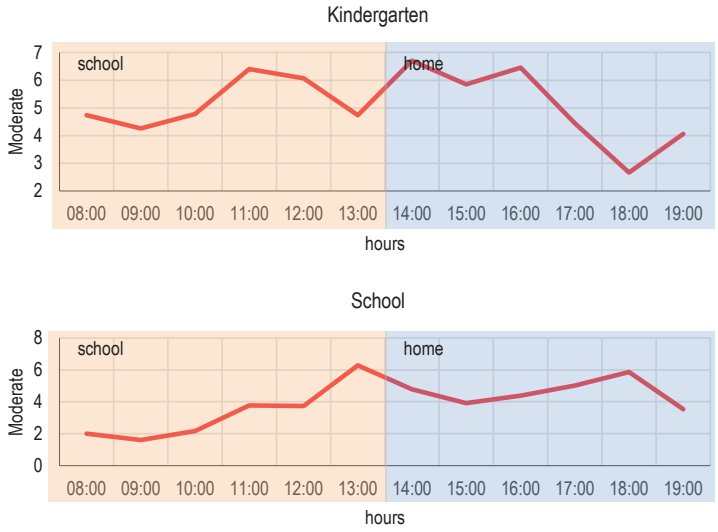

Figure 3. Moderate bahaviour of children during education and in the house between 8 am–8 pm

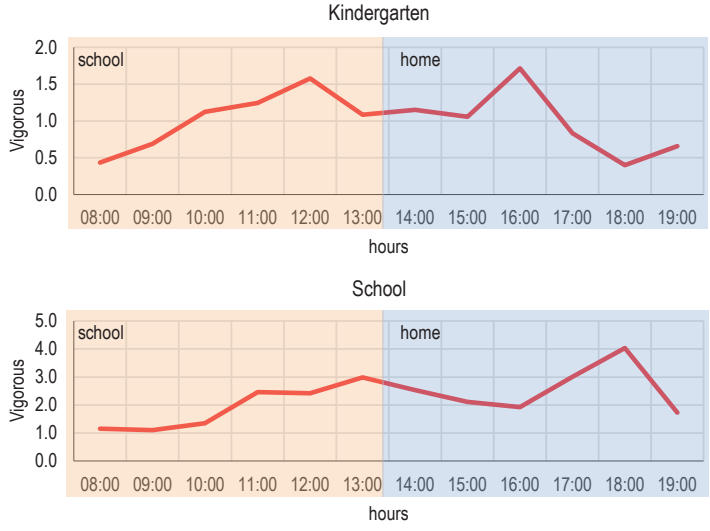

Figure 4. Vigorous behaviour of children during education and in the house between 8 am–8 pm

When analysing the moderate efforts it is noted that in kindergarten this parameter increases gradually from 10 a.m. and is on the same level until 4 pm, that gives approximately a total of 8% of the time spent in this way. In turn, in school this parameter remains almost constant throughout the study time and this gives almost 6.5% of the time spent in this way.

Analysing the efforts at a very high intensity, it is noted that this parameter in the kindergarten is growing with the start of classes, it takes place around 12:30 pm to maintain more or less stable and at about 5 pm it gradually decreases. This gives us approximately 2% of the time spent in this way. In turn, at school this parameter remains almost constant throughout the study time with a slight tilt at 6 pm and this gives almost 4% of the time spent in this way.

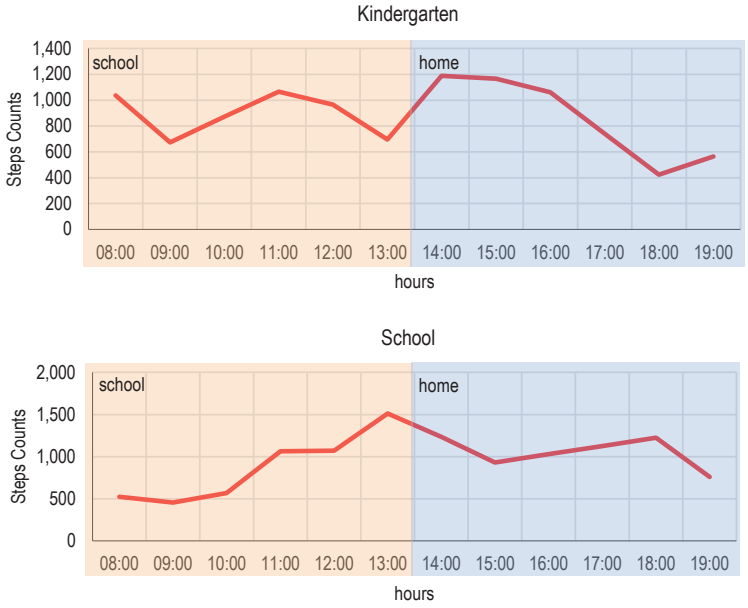

Figure 5. Distribution of the amount of steps children during education time and in the house between 8 am–8 pm

In the case of the number of steps in the kindergarten this parameter increases quickly from the start of the test, with small fluctuations until 4 pm, to decrease in the afternoon time. The average number of children's steps is 9,700. In the school it is growing much slower, to achieve culmination at 1 pm, thus maintaining the similar value until 6.30 pm. The average number of steps is 11,500.

Discussion

By comparing other results in this area of research (Steele et al., 2010; Carson, Cliff, Janssen, Okely, 2013; Telford et al., 2013), it can vary for example in terms of: division of the day during test, duration of test, sex, and not significant differences of test equipment (various accelerometers, pedometers, phone applications). In the selected parameters there are no significant differences. But one can see that children at school and kindergarten spend

their time more actively despite the forced sitting position between 8 am–1 pm. The reason for the increased activity may be so called spontaneous activity. In turn, children from kindergarten despite the greater amount of time spent on the active games often present sedentary behaviours. According to the analysed parameters (sedentary activities, light and moderate one) one can see some common features among tested group in the school, where the parameters remain stable, and in kindergarten these behaviours are subjected to some fluctuations during the day (moderate and high-intensity one). In the United Kingdom a tested group of 9–10 years old children indicated greater physical activity out of the school. This may be caused by the break in the studies from 7 am to 10.00 am (Steele et al., 2010). Sedentary activities in tests (Telford et al., 2013) remained at the level of 40% of the spent time during the day. It is worth adding, that in those studies, the respondents were in the age range from 8–12 years. In turn, in the tests (Carson, Cliff, Janssen, Okely, 2013) the average while staying at school was about 35% of spent time, and after school about 29%. Studies of the author indicate that in case of kindergarten it was 35%, school – 33%, which seems to be the better result. Efforts at a very high intensity take place more frequently at school. For a comparison of the studies (Thompson et al., 2009) the average was 3.5, in turn in the tests (Russell et al., 2006) the average was around 5.0. In these studies, one can note a lower level of high-intensity activity, which is a result of sedentary form of classes (kindergarten – an average of 1.5 and the school – average of 2). It is observed that in time out of school, kindergarten the value of this parameter slightly increases.

About 84% of the intervals observed indoors in preschool, are characterized by sedentary behaviour (Brown et al., 2009). Regarding the environment for physical activity, the assessments of the physical space of preschools by direct observation, higher total scores consecutively reported higher values of physical activity in relation to low scores (Bower et al., 2009). This fact demonstrates the positive influence of the environment conducive to the practice of physical activity in preschools.

The recommended number of steps per day is minimum 10,000 (Hills, Mokhtar, Byrne, 2014). Children and young people should make 12,000 steps per day. In turn, Tudor-Locke (Tudor-Locke, Lee, Morgan, Beighle, Pangrazi, 2006; Tudor-Locke et al., 2011) write that boys should make 13,000–15,000 steps a day and girls 11,000–12,000 steps a day. The results of Step Counts were much higher (kindergarten – 9,700 on average, school – 11,500 on average) than in the studies of Vale (Vale, Trost, Duncan, Mota, 2015) where boys made 9,225 steps a day and girls 9,177 steps a day, and Gabel (et al. 2012) – 8,968 steps per day on average. Otherwise, according to Pagels, Boldemann, Raustorp (2011) 7,313 steps a day on average and only in the tests (Tanaka, Tanaka, 2011) they were much higher and gave the result at the level of 13,000 steps per day on average. The research involves the need for attempt to answer the research questions on the material. According to research, there is small difference in physical activity between pupils from the school and from the kindergarten, with the benefit of pupils from school. It is the most visible in the number of steps, where children from school achieved much better results (11,500 steps) than children from kindergarten (9,700 steps). One can also point out at time intervals between tested groups, where a moderate and higher intensity activity increases and it is maintained by children at school in the afternoon. In turn, in preschool children one will see a large drop from the 4 pm in these parameters. Another research question was supposed to answer the question which part of the day is more active. Parameter analysis of moderate activity indicates the same level in both groups, in turn, higher-intensity activity parameter is higher in the afternoon among children at school.

The need for diagnosis and monitoring of physical activity should be pointed out.

New opportunities in this aspect create objective methods for measuring with the use of so-called motion sensors (pedometers), acceleration measures (accelerometers), devices for monitoring physiological parameters (heart rate monitor) as a support, and later as well as alternatives for research questionnaires

At the time of the introduction of accelerometers for research on physical activity in the world, research groups were small due to the small number of devices. Every year, the number of these devices increased. This is mainly dictated by the amount of equipment. The author began his research in 2013 with one device. Today, he has 15 devices at his disposal and he cooperates with the medical department of the University of Rzeszów, which owns about 60 devices.

Conclusions

On the base of the studies carried out, the following conclusions were constructed:

1. There is more physical activity at school (parameters – vigorous acitivity and counts steps) compared to kindergarten.
2. Time spent in kindergarten and school (parameters – vigorous acitivity and counts steps) is more active than time spent at home.
3. It was noted that during the stay at school / kindergarten children are characterized by higher level of physical activity.

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