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PEDAGOGY of Physical Culture and Sports

ORIGINAL ARTICLE

The effects of six-week slow, controlled breathing exercises on heart rate variability in physically active, healthy individuals

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection*

Abstract

Purpose: Heart rate variability (HRV) provides information about sympathetic-parasympathetic balance. The effects of different types of physical exercises on HRV have been investigated so far. The purpose of the current study was to evaluate the chronic effects of six-week slow and controlled breathing exercise on HRV in physically active, healthy adults.

Material: A total of 22 individuals (11 female, 11 male) participated in the study voluntarily. The experimental group (EG) attended to the breathing exercises for 15 minutes per day, three days a week for six weeks. Neither the EG nor the control group (CG) did join in any regular physical activity program during the study. Both groups participated in the HRV measurements before and after the six-week of process.

Results: Only the EG showed statistically significant changes in some HRV parameters. The alterations observed in LF:HF ratio, HFnu, and LFnu parameters were to reflect the increase in parasympathetic activity. Although the changes in the other parameters of HRV such as SDNN, SDSD, RMSSD, TP, HF, LF, and VLF were also related to increased vagal activity, these alterations were not significant. However, no significant change was found in the CG.

Conclusions: These results show that only the slow, controlled breathing exercises for six weeks could be used to improve parasympathetic activity in physically active individuals. A study could be designed where the duration is kept over 8 weeks, and the effects of physical exercises only, breathing exercises only, and physical + breathing exercises together on HRV are examined.

Keywords: heart rate variability, breathing exercise, autonomic nervous system

Introduction

Heart rate variability (HRV) can be defined as an electrocardiographic method which provides information about the both sympathetic and parasympathetic activity [1]. Due to the fact that autonomic nervous system (ANS) is considered as a marker of heart functions, and related to cardiovascular health, HRV has been widely used as a non-invasive method to evaluate the autonomic nervous system's functions [2, 3]. In addition to the field of health sciences, HRV measurements are also used in sport and exercise sciences to monitor the recovery process after physical activities with different type and intensities [4-6]. The general expectation is to increase the effectiveness of parasympathetic activity both in health and sport and exercise sciences. In order to increase either acute or chronic vagal activity, several exercise or recovery methods have been implemented so far [6-9], and an improved HRV was found related to enhanced level of physical fitness [10, 11].

Alternatively, to the physical exercises, breathing exercises have also been utilized to enhance the activity of ANS. It was reported that breathing could be considered essential for life as well as for protection from diseases and to improve quality of life, health and energy balance [12]. Therefore, some studies investigated the effect of breathing exercises in different groups in the literature. For instance, Pal et al. [13] found an improved vagal activity as a response to the three-month slow breathing exercise in young, healthy subjects. In another study, the acute effect of slow breathing exercises was caused increased vagal activity when compared fast breathing exercises [14]. The effects of slow breathing exercises were examined also in individuals with some diseases. Some of these studies reported that controlled or uncontrolled slow breathing exercises caused a decrease in blood pressure [15, 16], an improvement in pulmonary functions [17, 18], chronic insomnia [19, 20], chronic heart failure [21], and anxiety [22]. As slow breathing exercise is a non-pharmacological method, and easy to perform, it was frequently utilized to improve the autonomic regulation in individuals with different diseases by researchers.

When studies are examined, it can be understood that a high level of vagal tone is associated with a lower level of disease. This emphasizes that an improved HRV provides a better level of health, and slow breathing exercise is one of the methods to enhance the HRV [23]. Although slow breathing exercises have been studied with an increasing interest in recent years, the number of the studies examining the chronic effects of slow breathing on ANS in healthy individuals is still limited. Therefore, the aim

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of the present study was to investigate the chronic effects of six-week slow and controlled breathing exercises on the sympathetic and parasympathetic sub-branches of the autonomic nervous system in physically active, healthy adults. It was hypothesized that both time- and frequency-domain parameters of HRV would statistically change showing an increase in parasympathetic activity in the experimental group.

Material and Methods

Participants

A total number of twenty-two healthy subjects participated in the study voluntarily. They were randomly divided into the experimental and control groups. Individuals with lower level of physical activity, who do not perform at least 150 min of physical activity at the level of 3-6 MET per week, athletes, and individuals, having any diseases, excluded from the study. Similarly, people, who had respiratory problems up to six months before the study, were also excluded from the study. All participants were informed about the study design, were explained about the possible benefits and risks of the research and were also taught the correct diaphragmatic breathing, in the first meeting. After familiarization, all subjects were given a written informed consent form which was prepared according to the Declaration of Helsinki (code DoH-Oct2013). Table 1 demonstrates information about the participants.

Study design

This study was designed to evaluate the effects of six-week slow, controlled breathing exercises on HRV in physically active, healthy individuals. In order to achieve this aim, subjects were taught the correct diaphragmatic breathing, to inhale through the nose and exhale through the mouth, in the first, familiarization meeting. After that, participants, in the experimental group, visited the laboratory 3 days a week, for six week and attended to 15-min breathing exercise sessions. All subjects participated in the HRV measurements before starting the study and one day after the study ended.

Exercise protocol

The slow and controlled breathing exercises were performed in quiet room only by the experimental group. Breathing exercises were performed with 10 sec of diaphragmatic breathing cycles (6 breaths/min), including 5 sec of inhalation and 5 sec of exhalation, for 15 minutes per day, three days a week for six weeks. All the participants were in supine position one meter apart from each other during each breathing session, and they were asked not to move or speak during the exercise. To provide the subjects to easily track the 5 sec of inhalation and 5 sec of exhalation cycles, a large computer screen was projected on the ceiling showing the 5-sec time flow. This 15-min diaphragmatic breathing cycle was repeated 3 days a week with a minimum interval of one-day break for six weeks.

HRV measurements

The HRV measurements, before and after the six-week breathing exercise program, in both groups were performed in the performance laboratory in a quiet environment. The humidity of the laboratory was kept under 50 %, and the temperature between 20-22° C by using an air conditioner. All the data were collected between 3 to 5pm in two separate days. Subjects were asked to stop eating at least two hours prior to the measurements. They were also warned not to exercise, and not to consume alcohol within the 24 hours before the test, and to urinate within the 30 min before the test. Participants' caffeine intake was also limited within the previous 12 hours of the test. The data were obtained in supine position on a stretcher while the male participants were wearing only shorts and female participants shorts and sport bras. The HRV data were collected by using OmegaWave 800 (OW, Oregon, USA) device, and took each participant 5 minutes. Before the placement of three thoracic Wilson electrodes and four Limb electrodes subjects were told not to talk or move during the measurements, and after three min of resting phase the HRV recording was started. The parameters obtained from HRV recording were SDNN, SDSD, RMSSD, TP, HF, HFnu, LF, LFnu, and VLF.

Statistical analysis

All analyses were performed using the SPSS v.22 (SPSS Inc., Chicago, IL, USA). At first, the distribution of data was tested to determine if the test to be used for average comparison is parametric or not. Normality distribution was tested with Shapiro Wilk, as in both groups the number of participants was below 50. Average differences were determined with the parametric Paired Sample *t*-Test for the data where distribution is normal and with the nonparametric Wilcoxon Test for the data where distribution was not normal. An alpha value of 0.05 was accepted for all the statistical analyses.

Results

Table 2 represents the results of the tests performed before and after the six-week breathing exercises by the experimental group. According to the results it could be seen that the LF:HF ratio ($p<0.01$), HFnu and LFnu values

Table 1. Demographic information of the participants.

Parameters	Age (year)	Body height (cm)	Body weight (kg)	Body mass index
Experimental Group (6 male, 5 female)	21.36 ± 1.56	175.36 ± 7.95	66.63 ± 11.83	21.55 ± 2.96
Control Group (5 male, 6 female)	23.10 ± 1.79	169.60 ± 6.70	59.80± 9.97	21.66 ± 3.28

($p<0.05$) changed statistically. The percentage alteration in LF:HF ratio was 34.17 %, in HFnu 25.69 %, and LFnu 23.05 %. However, no statistically significant difference was found in SDNN, SDSD, RMSSD, TP, HF, LF, and VLF parameters in the experimental group.

Table 3 shows the results derived from the control group. When the findings, obtained from the control group, were examined, no statistically significant change was found in any of the HRV parameters.

Discussion

The present study aimed to understand the chronic effects of slow, controlled breathing exercises on HRV parameters in physically active, healthy individuals. Therefore, subjects participated in breathing exercises for 15 minutes per day, three days a week for six weeks. In accordance with the literature, respiratory rate was determined as six per minute [24]. Another substantial issue besides breathing rate was inhalation and exhalation time ratio (I:E ratio). Different types of I:E ratios have been investigated to observe the changes in HRV so far. While some studies have found that breathing with short inhale followed by long exhale is tending to increase the vagal activity more when compared breathing with long inhale followed by short exhale [25, 26], the I:E ratio did not affect the effectiveness of vagal tone in some other research [27-29]. Thus, each diaphragmatic slow breath cycle was consisted of 5 sec of inhale, and 5 sec of exhale components in the current research.

According to the results, statistically significant changes were seen only in the experimental group. These frequency-domain parameters of HRV were LF:HF ratio, HFnu, and LFnu. LF:HF ratio showed 34.12 % decrease ($p<0.01$). The LF:HF ratio is considered one of the most important components of HRV, and it is defined as sympathovagal balance. The LF:HF ratio is expected 0 to 2 during the day, and increased LF:HF ratio is associated with sympathetic activity. Thus, observing 34.12 % decrease in LF:HF ratio in the present study could be explained with increased vagal tone. Similarly to LF:HF ratio, LFnu is also evaluated as a marker of both sympathetic and vagal activity. Therefore, decreased LFnu (23.05 %) could be related to the increased parasympathetic effect after six weeks of slow, controlled breathing exercises ($p<0.05$)

Table 2. HRV results of the experimental group.

Parameters	Pre-test	Post-test	*P*	Change (%)
SDNN	43.27 ± 17.51	50.55 ± 19.56	0.299	+ 16.82
SDSD	51.45 ± 33.60	58.36 ± 34.88	0.581	+ 13.43
RMSSD	40.09 ± 26.22	46.00 ± 27.44	0.683	+ 14.74
TP	745.73 ± 656.35	1021.64 ± 847.56	0.657	+ 37.00
LF:HF	1.26 ± 0.62	0.83 ± 0.71	0.007**	- 34.12
HF	365.64 ± 441.20	694.45 ± 697.53	0.213	+ 89.92
HFnu	47.29 ± 12.66	59.44 ± 20.23	0.024*	+ 25.69
LF	317.18 ± 229.49	267.91 ± 183.37	0.534	- 15.26
LFnu	52.71 ± 12.66	40.56 ± 20.23	0.024*	- 23.05
VLF	64.00 ± 37.53	58.82 ± 21.37	0.766	- 8.09

SDNN: standard deviation of all NN intervals; SDSD: standard deviation of the successive differences between adjacent NN intervals; RMSSD: square root of the mean of the sum of the squares of differences between adjacent NN interval; TP: total power [ULF+VLF+LF+HF (>0.4 Hz)]; LF:HF: ratio of LF-to-HF power; HF: absolute power of the high-frequency band (0.15-0.4 Hz); HFnu: normalized HF spectral power; LF: absolute power of the low-frequency band (0.04-0.15 Hz); LFnu: normalized LF spectral power; VLF: absolute power of the very-low-frequency band (0.0033-0.04 Hz). * $p< 0.05$; ** $p< 0.01$

Table 3. HRV results of the control group.

Parameters	Pre-test	Post-test	*P*	Change (%)
SDNN	72.09 ± 26.30	71.73 ± 34.96	0.945	- 0.50
SDSD	102.73 ± 44.56	95.64 ± 65.89	0.606	- 6.90
RMSSD	81.27 ± 35.74	74.91 ± 51.63	0.547	- 7.82
TP	2283.73 ± 1722.94	2236.00 ± 2227.73	0.110	- 2.09
LF:HF	0.75 ± 0.67	0.78 ± 0.54	0.656	+ 4
HF	1324.82 ± 1040.69	1322.09 ± 1558.88	0.286	- 0.20
HFnu	63.20 ± 17.61	59.89 ± 13.82	0.607	- 5.23
LF	836.91 ± 893.79	777.82 ± 747.30	0.722	- 7.06
LFnu	36.80 ± 17.61	40.11 ± 13.82	0.607	+ 8.99
VLF	122.00 ± 69.71	136.09 ± 107.30	0.604	+ 11.55

SDNN: standard deviation of all NN intervals; SDSD: standard deviation of the successive differences between adjacent NN intervals; RMSSD: square root of the mean of the sum of the squares of differences between adjacent NN interval; TP: total power [ULF+VLF+LF+HF (>0.4 Hz)]; LF:HF: ratio of LF-to-HF power; HF: absolute power of the high-frequency band (0.15-0.4 Hz); HFnu: normalized HF spectral power; LF: absolute power of the low-frequency band (0.04-0.15 Hz); LFnu: normalized LF spectral power; VLF: absolute power of the very-low-frequency band (0.0033-0.04 Hz). * $p< 0.05$; ** $p< 0.01$

when the changes in LF:HF and HFnu are taken into account [30]. Another finding showing improved vagal activity was HFnu with an increase of 25.69 % ($p<0.05$). Other frequency-domain parameters TP (+ 37 %), HF (+ 89.92 %), LF (- 15.26 %), and VLF (- 8.09 %) did not show significant alterations. Although, the changes in time-domain parameters were also related to improved vagal activity, these were not statistically significant, contrary to the hypothesis. The SDNN (16.82 %), SDSD (13.43 %), and RMSSD (14.74 %) increased after the six-week breathing exercises. Therefore, the duration of the study may be planned longer than six weeks in the future studies. In spite of the changes observed in experimental group, no significant change was observed in any HRV parameters in the control group.

There are number of studies in the literature which investigated chronic effects of different paced breathing exercises on individuals with chronic diseases. Das and Ferdousi [31] found increment in resting heart rate, short and long term SDRR values of HRV after three-month slow breathing exercises in transfusion dependent thalassaemic patients. Mourya et al. [32] compared the three-month slow and fast breathing exercises on autonomic functions in patients with stage one essential hypertension, and reported that slow breathing was more correlated with an improved ANS activity. Again, after a three-month slow breathing exercises the average heart rate, mean RR intervals, SDNN, and RMS values of HRV measurement showed a significant improvement in patients with type 2 diabetes mellitus [33]. Since respiratory functions are highly correlated with HRV, and strengthening the respiratory muscles that help breathing [34] is considered as a result of breathing exercises, Han and Kim [17] investigated the effects of four-week breathing exercises combined with upper body exercises in adults. They found that both combined breathing and upper body training, and only breathing training caused significant increases in forced vital capacity (FVC) ($p<0.05$), and the forced expiratory volume (FEV) value was higher in combined training group. In a similar study it was found that three-month slow breathing exercises are more effective in some pulmonary functions such as FVC, FEV_1, and FEV_1/FVC in patients with major depressive disorder [18]. Kawecka Jaszcz et al. [21] found significant changes in physical exercise capacity, ejection fraction, and also sleep disorders after slow breathing exercises performed in patients with chronic heart failure with a frequency of 6 breaths per minute for three months. Zou et al. [35] stated in their meta-analysis that slow breathing could reduce the resting heart rate, and systolic and diastolic blood pressure in patients with cardiovascular diseases.

The chronic effects of slow breathing exercises in healthy individuals have also been examined in a limited number of studies. In some of them it was stated that activities such as yoga, involving slow breathing sessions named pranayama, can help to control and enhance the ANS by improving the parasympathetic activity [36-38]. Turankar et al. [39] pointed that slow, controlled breathing exercise during the pranayama phase for 20 minutes, twice a day for 7 days decrease resting HR, and sympathetic tone of the ANS. Each breathing cycle consisted of 6 sec inhales through the left nostril, 6 sec of hold and 6 sec of exhale through the right nostril. These changes, occurred only in 7 days, were observed in healthy male and female individuals. Another study which was performed in healthy adults showed that slow and controlled yoga breathing exercises five days a week for six months provides positive alterations in cardiac autonomic modulation by increasing the parasympathetic activity [40]. Each breathing session consisted of 5 cycles for 5 times with 2 min of resting intervals, and subjects did 3-6 breath/min during the whole implementation. Authors recorded significant changes in resting heart rate, SDNN, RMSSD, NN50, pNN50, Lfnu, Hfnu, and LF:HF ratio. In Tharion et al.'s study [41], healthy participants performed breathing exercises at a rate of 6 breaths per minute (4 sec of inspiration, and 6 sec of expiration time) for half an hour a day for one month, and statistically significant changes in HF power, LF+HF power, arterial blood pressure, and respiratory rate in the experimental group were found while it was reported no change in the control group. The findings of the above-mentioned studies are in line with the results of the current research. Accordingly, it can be seen that slow breathing exercises in different cycles reveal significant changes in different parameters of HRV.

As a result, the present study proved that slow and controlled breathing exercises provide enhancement in parasympathetic activity in physically active, healthy adults. When positive effects of an improved autonomic nervous system taken into account, this type of exercise could be recommended for healthy adults to improve their heart functions. Since HRV is highly correlated with cardiovascular and metabolic diseases, this could reduce the risk of prevalence to fatal diseases [23]. In addition, athletes can benefit from slow and controlled breathing exercises. When a rapid recovery in heart functions is aimed, athletes could implement slow breathing exercises at the end of a training session, especially after a vigorous physical activity. This would help with speeding up the recovery process. The duration of the study might be planned for more than six weeks or the number of slow and controlled breathing exercise sessions could be increased in future studies, since the substantial improvements observed in time-domain parameters were not significant in the current research. Future studies could also compare the effectiveness of physical and breathing exercises on HRV simultaneously, by adding a physical exercise group, a breathing exercise group, a physical + breathing exercise group, and a control group.

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Conflict of interest
The authors declare no conflict of interest.

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ORIGINAL ARTICLE

The relationship between sprint performance and both lower and upper extremity explosive strength in young soccer players

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Abstract

Purpose: Sprint performance plays a major role in success of field-based team sports such as soccer. The aim of this study was to evaluate the relationship between sprinting performance and both lower and upper extremity explosive strength in young soccer players.

Material: One hundred forty-seven soccer players (mean±SD; age 11.6±1.66 years, height 143.2±11.8 cm, body mass 37.1±10.2 kg and training experience 1.11±1.5 years) voluntarily participated in this study. The sprinting performance of each player was determined using their 5, 10, 20 and 30m single sprint times. The lower and upper extremity explosive strength were evaluated by standing long jump and medicine ball throwing tests respectively. Prior to the study, each of the players was given detailed information about the risks and injuries they could encounter during the study, and parental consent was obtained by their signatures on informed voluntary consent forms since the subjects were under the age of 18. Permission to conduct the study was obtained from Ankara University Medical Faculty's Surgical and Medical Research Ethics Committee.

Results: The results indicated a strong relationship between sprinting performance and horizontal jump performance (r=-.671– -.764; p=0.001) and also a large relationship between sprinting performance and upper extremity strength (r=-.633 – -.703; p=0.001). The sprint performance (n=147) also significantly correlated with body weight (r=-.345 – -.373; p=0.001) and height (r=-.445 – -.505; p=0.001).

Conclusions: The study results suggest that upper extremity strength is as important as the lower extremity strength for sprinting performance and that trainers should emphasize lower and upper extremity strength in training intended to improve sprinting performance.

Keywords: sprinting performance, standing long jump, explosive strength, football

Introduction

For reasons such as high physical requirements, frequent change in exercise intensity and the vast number of movement profiles, in soccer, both adults and children must maintain their physical capacity at an optimal level. For a soccer player, this relates to having several superior physical characteristics. Among these characteristics, sprinting speed plays a major role in the success of field-based team players such as soccer players. For instance, it was reported in an analysis that a total of 360 goals scored during the 2007-2009 soccer seasons of Germany's Bundesliga and that 45% of the goals scored were achieved by straight sprinting and that straight sprinting was the dominant activity of players when scoring [1].

The average sprinting distance of a player during a soccer match was reported to be 600 meters [2]. 96% of this distance was shorter than 30 meters [3]. Accordingly, velocity, particularly the maximum velocity before reaching 30 meters, is a subject to be addressed. Defining the factors that affect sprinting velocity in the first 30 meters will contribute to improving sprinting performance. Lower and upper extremity strength is also considered to be affect sprinting performance. The standing long jump test can be used to determine lower extremity strength. This is a single jump attempting to make as much horizontal movement as possible in the air with both feet parallel to each other [4]. It is generally used to evaluate the lower extremity explosive strength of athletes [5, 6]. The medicine ball throw test was also used to measure upper extremity explosive strength.

Individual physical and physiological properties should be taken into account when evaluating the results of these tests. Age is an important factor. The movement system is affected by age-related changes, and these changes affect physical performance [7]. The improvement of acceleration and maximum velocity is possible through proper exercises during childhood [8]. Some studies examined the relationship between velocity and strength in soccer in the literature [9, 10]. The inadequacy of the studies on the relationship between sprinting performance and both lower and upper body explosive strength in young soccer players is the starting point of this study.

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In a study carried out on 15 soccer players with an average age of 16y, Köklü et al. [9] found moderate-strong relationships between 10 and 30m sprinting performances and vertical jump performance (r =-.599). Furthermore, in a study carried out on 14 soccer players with an average age of 20y, Lopez-Segovia et al. [10] found a relationship between the vertical jump performance and sprint performance of the players (r=-.46 − -.61) . These studies indicate the importance of the explosive strength in their respective populations. In our study, the objective was to evaluate the relationship between sprinting performance and the lower and upper extremity explosive strength in young soccer players.

Material and Methods

Experimental Approach to the Problem

This study was designed to investigate the relationships between sprint performance (times over 5, 10, 20 and 30m) jump performance (horizontal jump performance) and ball throwing performance (medicine ball throwing test) in trained (4 times per week) young soccer players.

Sprint performances over 5, 10, 20 and 30 m were selected because these are representative of sprint distances covered during competitive soccer matches [11], whereas the jump and ball throwing protocols were selected because they are commonly used to assess such athletes.

Participants

One hundred forty-seven male soccer players (mean±SD; age 11.6±1.66 years, height 143.2±11.8 cm, body mass 37.1±10.2 kg and training experience 1.11±1.5 years) voluntarily participated in the study. The study was carried out in the 2013-2014 soccer season before the competition period and after the preparation period, during which the soccer players were not engaged in any other training or soccer match. Prior to the study, each of the players was given detailed information about the risks and injuries they could encounter during the study, and parental consent was obtained by their signatures on informed voluntary consent forms since the subjects were under the age of 18. Permission to conduct the study was obtained from Ankara University Medical Faculty's Surgical and Medical Research Ethics Committee.

Research Design.

Tests

All athletes rested the day before testing and were asked to attend testing in a fed and hydrated state, similar to their normal practices before training. In addition, participants were asked to avoid caffeine consumption 24h before testing. Before the tests, soccer warm-up exercises were performed for 15 minutes. Then the physical measurements (height and weight) and performance tests (5, 10, 20, 30m sprinting, medicine ball throwing test and standing long jump test) were conducted.

The Five, Ten, Twenty and Thirty Meter Sprint tests

An electronic timing system (Prosport TMR ESC 2100, Tümer Engineering, Ankara) with the capability to record a hundredth of a second was used to determine 5, 10, 20, 30m sprint velocities. Photocells were placed at the starting point, 5, 10, 20, 30m distances. At the starting line of the 30 meters distance, the subjects took a standing position with one of their knees in the front and the other in the back. Their velocities at 5, 10, 20, 30m were recorded in meters/second. Each player ran twice, and 3 minutes of resting time was allowed to each participant between the two runs.

The Medicine Ball Throwing Test

A medicine ball weighing 1 kilogram with a 66-centimeter circumference and a measuring tape were used for the ball throwing test. Players were asked to stand at a line marked with tape and to throw the medicine ball forward over their heads in the throw-in position. The ball's first point of contact with the ground was measured using the measuring tape and recorded. The best one of two throws were used for analysis.

The Standing Long Jump Test

The players were asked to open their legs shoulder wide and stand with their feet behind the line. A ruler was used to ensure that their tiptoes were at the same distance from the line. They were instructed to bend their knees and sway their arms backward. Then, they were asked to jump as far as possible and stand still at the point where they landed. The distance from the heel nearest to the line was measured. The best one of two jumps were used for analysis.

Statistical Analysis:

Statistical analysis was performed using SPSS 19.0 software. The distribution of the data was evaluated using the Shapiro-Wilk normal distribution test and variance and homogeneity were tested using Levene's test. Due to the non-parametric character of the data, the relationships between the parameters were evaluated using Spearman's correlation test.

Results

The soccer players' physical characteristics and test performance are listed in Table 1.

There was a strong relationship between the 5, 10, 20, 30m sprint performance and lower extremity explosive strength (r=-.671 − -.764) , also the upper extremity explosive strength correlated with 5, 10, 20, 30m sprint performance (r=-.633 − -.703).

The correlation coefficients were highest between the 30m sprint and standing long jump performance (r=-.764; p=0.001) virtually in all cases compared to 5, 10 and 20m sprint performance. The relationship between the sprint performance of a sub-group of 13-14 years old (n=57) participants and their standing long jump performance (r=-.731; p=0.001) was stronger compared to 9-10 (n=38) and 11-12 (n=52) years old sub-groups in all sprint distances of 5, 10, 20 and 30m (Table 2).

There was a strong correlation between the 5, 10, 20, 30m sprint and medicine ball throwing performance (n=147; r=-.633 − -.703; p=0.001). However, the sprint performance of the sub-groups of 9-10, 11-12 and 13-14 years old participants had a relatively low correlation with medicine ball throwing performance (Table 2).

The sprint performance of the participants (n=147)

Table 1. The soccer players' physical characteristics and test performances (n=147)

Characteristics	Mean	Standard Deviation
Age (years)	11.7	1.66
Height (cm)	143.6	11.8
Body mass (kg)	37.1	10.2
Training experience (months)	23.1	17.0
5m Sprint (s)	1.146	0.1
10m Sprint (s)	2.051	0.2
20 m Sprint (s)	3.698	0.3
30 m Sprint (s)	5.357	0.5
Standing Long Jump (cm)	154.51	22.4
Medicine ball throwing (cm)	470.17	144

Table 2. The correlation coefficients between sprint speed, standing long jump and medicine ball throwing performance.

Age	Task	5m Sprint	10m Sprint	20m Sprint	30m Sprint
9-10 years n=38	Standing Long Jump	-.347	-.367	-.496	-.503
	p	0.033	0.023	0.002	0.001
	Medicine Ball Throwing	-.408	-.530	-.503	-.430
	p	0.011	0.001	0.001	0.007
11-12 years n=52	Standing Long Jump	-.445	-.522	-.507	-.511
	p	0.001	0.001	0.001	0.001
	Medicine Ball Throwing	-.148	-.288	-.364	-.421
	p	0.296	0.038	0.008	0.002
13-14 years n=57	Standing Long Jump	-.569	-.616	-.665	-.731
	p	0.001	0.001	0.001	0.001
	Medicine Ball Throwing	-.411	-.488	-.434	-.410
	p	0.001	0.001	0.001	0.002
Total n=147	Standing Long Jump	-.671	-.721	-.740	-.764
	p	0.001	0.001	0.001	0.001
	Medicine Ball Throwing	-.633	-.692	-.700	-.703
	p	0.001	0.001	0.001	0.001

also significantly correlated with their body weight (r=-.345 − -.373; p=0.001) and height (r=-.445 − -.505; p=0.001).

Discussion

The aim of this study was to evaluate the relationship between the maximum velocity of young soccer players and their lower and upper extremity explosive strength. In consideration of the close relationship between these parameters and the rate of success in soccer, the relationship between these variables was evaluated, and statistically significant relationships were found.

There are other studies in agreement with the results of our study in terms of the relationship between maximum sprint velocity and horizontal jump performance. Jones & Lorenzo [12] reported a significant relationship (r=-0.64) between the 18.2 meter maximum velocity and horizontal jump performance of the athletes with an average age of 11.7. In the study conducted with young baseball players, Nakata et al. [13] found a strong relationship (r=-0.78) between 10 meter sprint maximum velocity and horizontal jump performance. Tambalis [14] investigated the relationship between 30 meter sprinting performance and horizontal jump performance of children between the ages of 7 and 10 and reported a moderate relationship (r=-.46). Additionally, Hammami et al. [15] found a moderate relationship (r=-0.40-0.48) between the maximum sprinting performance and vertical and horizontal jump performance of children (8-14 years old).

The relationship between sprinting performance and vertical jump performance has also aroused interest in the literature. Swinton et al. [16] reported a strong relationship (r=-0.52-0.82) between the 5-10-30 meter sprinting performance and vertical jump performance. In their study, Wisløff et al. [17] reported a moderate relationship between the vertical jump and maximum

velocity performances (r=-0.55- -0.60). Erikoğlu & Arslan [18] found a significant relationship between 30 meter sprinting and vertical jump performances. Köklü et al. [9] reported a strong relationship (r=-0.59) between maximum velocity of 30 meter sprint and vertical jump performance. They suggest that the relationship between maximum velocity and jump performance can be attributed to the high strength requirement of both activities with similar energy requirements. Comfort [19] found a strong relationship (r=-0.87) between maximum sprint velocity and vertical jump performance, and they underlined the importance of improving the lower extremity strength to improve sprinting and jumping performance. In addition, Cronin & Hansen [20] found a moderate relationship (r=−0.43 −0.66) between the vertical jump and 5-10- 30 meter sprinting performances of rugby players. In contrast to these studies, Chamari et al. [21] found no relationship between the 20 meter, 30 meter sprinting performance and vertical jump performance. These varying results are attributed to the varying ages, training conditions, sports as well as being elite or non-elite athletes.

This study indicated that the relationship between the sprinting performance and lower and upper extremity strength becomes stronger at increased sprinting distances. The 10 meter sprinting distance indicates acceleration, and the 30 meter sprinting distance indicates maximum velocity [22]. These results indicate that the lower and upper extremity explosive strength has a strong relationship with the maximum sprint velocity. This is attributed to the increased muscle strength requirement from the lower and upper extremity at increased sprinting distances. The study results also showed that the sprint performance enhances with age and the relationship between the sprint performance and both upper and lower extremity explosive strength becomes larger with age. In a study conducted with a large sample of boys (n=375; 11-16 years old), Meyers et al. [23] concluded that the additional leg compression increases with age and may provide beneficial effects in sprint performance.

The relationship between maximum sprinting performance and horizontal jump performance can be ascribed to the maximal activity requirement of both types of performances, both of which call for horizontal movement of the centre of gravity. In the literature, some studies investigated the relationship between the maximum velocity performance and upper extremity strength of athletes. Tambalis et al. [14] found a moderate relationship (r=-0.42) between the 30 meter maximum velocity and medicine ball throwing performance of children. As opposed to the present study, Jones & Lorenzo [12] found a weak relationship (r=-0.14) between the maximum velocity and medicine ball throwing performance of young athletes.

Conclusions

In conclusion, the relationship between the maximum sprint velocity and lower and upper extremity strength can be considered to be in direct proportion with explosive strength. The study results also suggest that upper extremity strength is as important as lower extremity strength, and that trainers should emphasize lower and upper extremity strength in training targeted to improve sprinting performance.

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Conflict of interest

The authors declare no conflict of interest

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ORIGINAL ARTICLE

Impact of the "Chalk" on perceived visual quality and the willingness to climb: a research on sports climbing

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Purpose: Rock climbing is a popular outdoor recreation and tourism activity practiced in natural areas. Rock climbing, like all of the other outdoor activities, has a variety of impacts on nature and visitors. Understanding these impacts is important for ensuring the sustainability of natural environments and activities practiced in these areas. The goal of this study was to analyze the impacts of chalk density on the rock surface, on the perceived visual quality and the willingness of participants to climb.

Material: The visual research method was used in the study to analyze the perceived visual quality of climbers. Photographing technique, one of the visual research methods, was utilized in the study to determine the perceived visual quality of climbers. Eleven photographs, prepared for this purpose, were presented to 213 voluntary participants and the obtained results were evaluated.

Results: Repeated measures analysis of variance test results indicate that the chalk level increase specifically designed and presented in the photographs statistically changed the perceived visual quality of participants. Impacts of the variables of gender, climbing experience, climbing level and chalk density level on perceived visual quality are compared with the ANOVA test. The results indicate that within-group variance in terms of the climbing level is statistically significant.

Conclusions: According to the results of the study, the increase in chalk use density on rock surfaces has a negative impact on the perceived visual quality and willingness of participants to climb.

Keywords: sports climbing, visual impacts, chalk, willingness to climb, perceived visual quality

Introduction

Demand for modern societies on outdoor recreations, which is a significant component of today's lifestyle, has dramatically increased in the last decade; these activities have become important for people living in even the most remote and pristine areas. Rock climbing is one of these activities which have drastically increased in recent years [1]. Many industrialized societies, particularly living in the U.S.A and Europe, have been showing an increasing interest in this activity. For instance, while there were 25 million of climbers in the U.S.A in 2008, this number will increase to 38-48 million by 2060 according to the estimations. On the other hand, it is predicted that the number of days in which climbing is practiced by these climbers per year will increase to 178-219 million [2]. The number of active climbers in Europe is more than two million and this number is increasing every day [3]. Owing to this increasing interest, rock surfaces which were once unapproachable now have to face unprecedented human pressure [1]. Although the popularity of this activity has been increasing, there are only a limited number of scientific/academic studies about the effects of this activity [4]. Most of the studies analysing the issue have focused on the changes in the structure and composition of vegetation structure on rock surfaces [5]. Although the impacts of rock climbing are not completely clear, current studies have indicated that vegetation on the rock surface is negatively affected by this increasingly popular activity [1, 6, 7]. On the other hand, the systematic compilation study by Holzschuh [8] indicates that lichens and plant species on rock surfaces can sometimes be negatively or positively affected by the activity according to variables, while snail diversity is negatively affected. In addition to these, Holzschuh [8] determined that the studies about the effects of rock climbing on bird diversity are limited. According to the researcher's findings, bryophytes are not affected by the activity. Holzschuh [8] states that there is not a single, commonly accepted idea or data about the impacts of rock climbing and it is necessary to conduct more studies focusing on determining, analysing and understanding these impacts.

Besides the effects of rock climbing on bio-diversity, the activity affects different dimensions of natural and human life. These effects can be classified by chipping and other mechanical wears such as polishing; the impact of chocks, pitons, and bolts; increased rock-fall rate; and mainly aesthetic damage caused by chalk and rope wear on soft rocks [9]. Aesthetic damages of outdoor activities on nature not only affect the environment but also change the experiences of visitors. Aesthetic factors and visual beauty have an impact on visitor preferences about outdoor activities; these factors direct tendencies and willingness of visitors. There is a direct, undeniable relationship between the wish of visiting a natural environment and the visual beauty and quality of that area [10]. On the other hand, the related studies in the literature indicate that visual beauty is one of the most important

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factors that affect the destination choices of outdoor recreation participators [11]. Owing to the reason, it is highly important to determine the factors that affect the visual quality or beauty for ensuring the sustainability of a destination. Unfortunately, there are only a limited number of studies focusing on the visual impacts of rock climbing [12]. Studies about the issue mostly focus on the visual impacts of fixed (bolt/piton) and mobile anchors. The studies in the related literature indicate that the anchors negatively affect the visual quality of rocks [13-15]. It is determined that the executives in various regions in the U.S.A either prohibited the use of fixed and mobile anchors in various rock climbing areas in the 1990s [12], or set some specific rules about the use of these materials during climbing.

Another negative visual effect of rock climbing results from the use of Magnesium Carbonate, known as "Chalk". This material has a white colour and it is a kind of powder; climbers use the powder to prevent their hands from sweating and to create a friction between their hands and rock surfaces [16, 17]. Magnesium carbonate is traditionally carried in a belt bag called "chalk bag". Climber puts his/her fingers in this bag, take some powder and climbs; every touch/grip leaves a white stain on the surface of rocks. Although this visual effect of chalk use is defined as "irritating" by climbers [18], the results of the studies on the issue indicate that the use of the material does not cause a statistically significant visual effect [12, 19]. At this point, it is important to note that while previous studies on the topic focused on situation assessment about chalk use, they didn't take the effect of the increase in chalk use into consideration. This is why; there is no data in the literature about the visual on climbing routes resulting from the increase in chalk use. The goal of this current study was to analyze the effects of the increasing chalk use on rock surfaces on perceived visual quality and the willingness of participants to climb.

Material and Methods

Sources of information.

The visual research method is used in the study to analyze the perceived visual quality of climbers. This method has been playing a significant role for a long time in the environment and natural resources studies. There are many studies especially on analysing environmental effects of recreational and touristic activities through the use of visual research method [20-24]. Photographs processed by computers have been used in recent studies for assessing quality standards about visitor experiences and specific components in outdoors [25]. A variety of studies support the relationship between the photographic evaluation method and direct (onsite) judgments of visitors. It is determined that the overlap ratio between the two methods is more than 80 % [26, 27].

A photograph of the sports climbing route taken by researchers is used in this study; Antalya – Olympus Sports Climbing Area is chosen as the study field. Route photograph angle, the surface of climbing and framing consistency, excluding any kind of foreign objects in the image, clarity of handles on the rock surfaces and climbing route are the criteria taken into consideration during the process of determining the route. The photograph determined for the research is transferred into a photo-editing program in the computer; magnesium carbonate marks on the climbing surface are cleaned with the same program. After these steps, magnesium carbonate marks are increased layer by layer, and a total of 11 different photographs with different magnesium carbonate layers are carefully formed.

Procedure

Sport climbing is the one of the most preferred and demanded branch of climbing therefore the sample was selected from in the sports climbers. Participator survey approach used in the related previous studies is used for determining the perceived visual quality of rock climbers in this study [28, 29]. The survey form prepared in the digital media is e-mailed to the sports climbing trainers and sportsmen who are members of the Turkish Mountaineering Federation. A total of 11 slides in a specific order in the survey are shown to the participators. They are required to evaluate each photograph in these slides according to two different types of 7 Point Likert scales. In the first evaluation stage, questions prepared for determining perceived visual quality are asked (1 point-very low visual quality and 7 points-very high visual quality). In the second evaluation stage, questions about the willingness to climb the route presented in the photographs are asked (1 point- I absolutely don't prefer to climb, 7 points- I absolutely prefer to climb). Questions prepared for the purpose of determining the demographic features of participators are presented in the last section of the survey.

Statistical Analysis:

Kolmogorov Smirnov test is used as the test of normalcy for evaluating the normality assumption of the data. Skewness and Kurtosis values of the obtained data are analyzed. According to the results, there is a normal distribution [30]. Frequency and means are commonly used for summarizing the data in visual research methods [31] are completed. As the study results are more complicated than the results obtained from the summaries of frequencies and means [32], ANOVA test is used for repeated measures analysis while Independent t-test is used for paired comparison tests.

Results

213 rock climbers voluntarily participated in the research. Fifty-nine participants are female while 154 participants are male (mean age: 31.44±9.84 years). Most of the participants have been practicing the activity for 1-5 years (49.3%). It is determined that most of the climbers who participated in the study have advanced (Classified by Draper et al. [33]) level climbing experience (see Table 1). Changes in the perceived visual quality of participants are measured with 11 photographs. It is determined that the obtained data is normally distributed. Repeated measures analysis of variance [(ANOVA (Greenhouse-Geisser)] test results indicates that the chalk level increase specifically

designed and presented in the photographs statistically changed the perceived visual quality of participants [F(1.95, 412.54)= 69.65, p<.01]. According to the Post hoc test result, based on Bonferroni correction, perceived visual quality score means of participants decreased from 4.95 (the first photo) to 2.98 (the last photo) (see Table 2). The results of the study show that the perceived visual quality of participants started to become negative with the photograph no.6 (Chalk density: 5 layers) (see Figure 1). Impacts of the variables of gender, climbing experience, climbing level and chalk density level on perceived visual quality are compared with the ANOVA test. The results indicate that within-group variance in terms of the climbing level is statistically significant [F (1.96, 408.91)=3.69, p<.05]. An increase in the chalk density in photos causes a decrease in perceived visual quality means of every group (Intermediate and lower, advanced and higher) (see Figure 2). According to the paired comparisons, there are not statistically significant results between two groups in the photos from 1 to 9 (p>.05); on the other hand, participants in the group 'advanced and higher' have lower perceived visual quality means in the 10th and 11th photos when compared to the other group (see Table 3) (p<.05).

Changes in willingness of participant to climb on the basis of the chalk effect are measured with 11 specifically prepared photos. Results of repeated-measures analysis of variance [(ANOVA (Greenhouse-Geisser)] test indicate that the chalk level increase presented in the photographs statistically changed the climbing willingness of

Table 1. Demographic Features

Gender	n	%	Age	n	%	Climbing Level	n	%	Climbing Experience	n	%
Male	154	27.7	18-25	58	27.2	Lower Grade	5	2.3	1-5 years	105	49.3
Female	59	72.3	26-34	74	34.7	Intermediate	97	45.5	6-10 years	53	24.9
			35-44	28	13.1	Advanced	102	47.9	10 years<	55	25.8
			45-54	13	6.1	Elite	6	2.8			
			55 <	8	3.8	Super Elite	-	-			

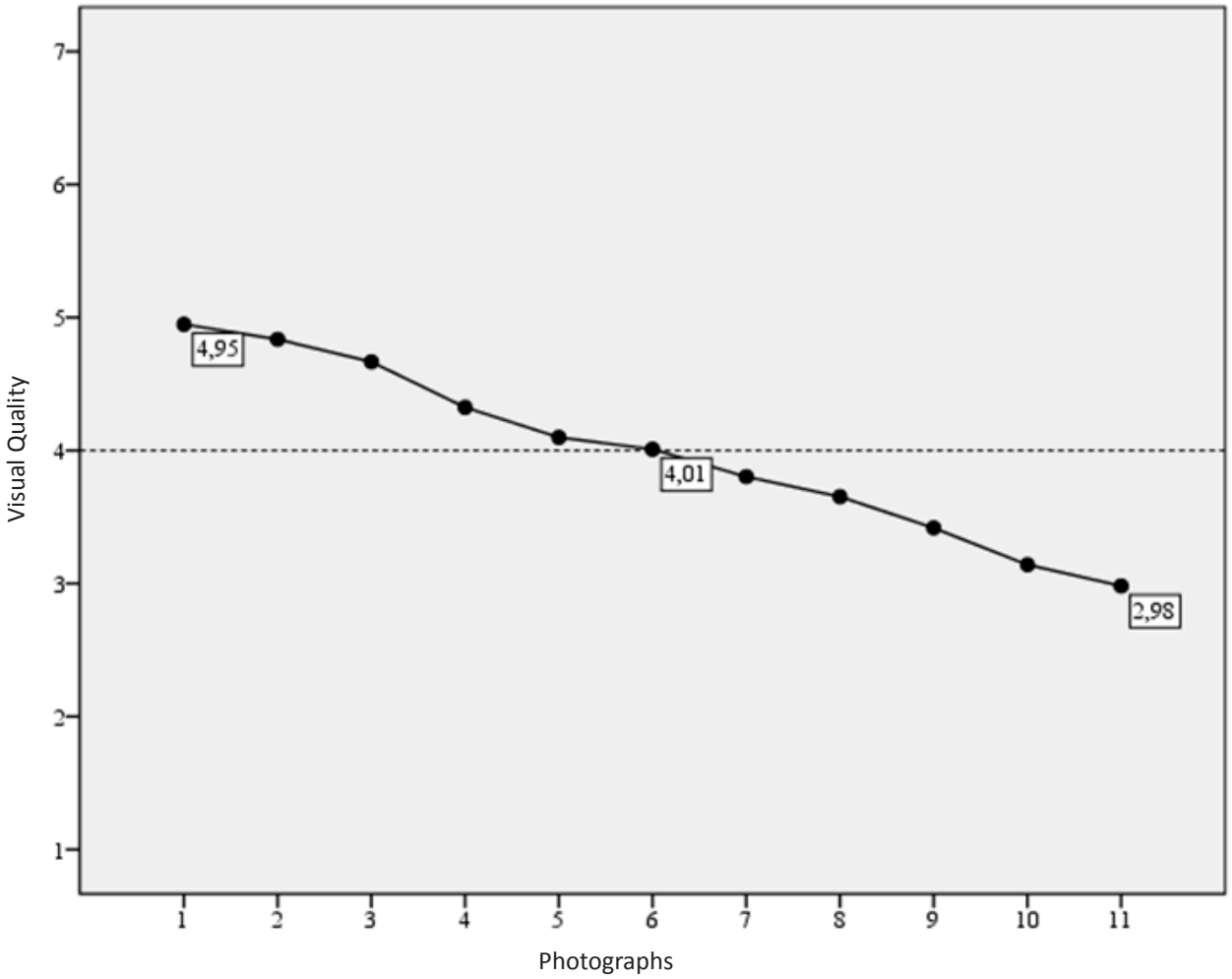

Figure 1. Curve of photographic visual quality of participants (Chalk density effect)

participants [F(1.95, 414.15)= 39.21, p<.01]. According to the Post hoc test result, based on Bonferroni correction, participant climbing willingness means decreased from 5.20 (the first photo) to 3.79 (the last photo) (See Table 4). The results of the study show that the climbing willingness of participants started to be negatively affected by the photograph no.10 (Chalk density: 9 layers) (see Figure 3). Impacts of the variables of gender, climbing experience, climbing level and chalk density level on climbing willingness are compared with the ANOVA test. The results indicate that within-group variance in terms of the climbing level is statistically significant [F (1.96, 408.43)=4.08, p<.05). An increase in the chalk density in photos causes a decrease in the means of every group

Table 2. ANOVA comparisons of visual quality perceptions of participants about chalk effect

	Variables		Bonferroni Comparisons*										
	Mean	**SD**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	4.95	1.70											
2	4.84	1.48	1.00										
3	4.67	1.48	.24	.54									
4	4.32	1.57	.00	.00	.00								
5	4.10	1.67	.00	.00	.00	.00							
6	4.01	1.74	.00	.00	.00	.00	.63						
7	3.80	1.79	.00	.00	.00	.00	.00	.00					
8	3.65	1.80	.00	.00	.00	.00	.00	.00	.00				
9	3.42	1.89	.00	.00	.00	.00	.00	.00	.00	.00			
10	3.14	1.96	.00	.00	.00	.00	.00	.00	.00	.00	.00		
11	2.98	2.10	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	

*p-value

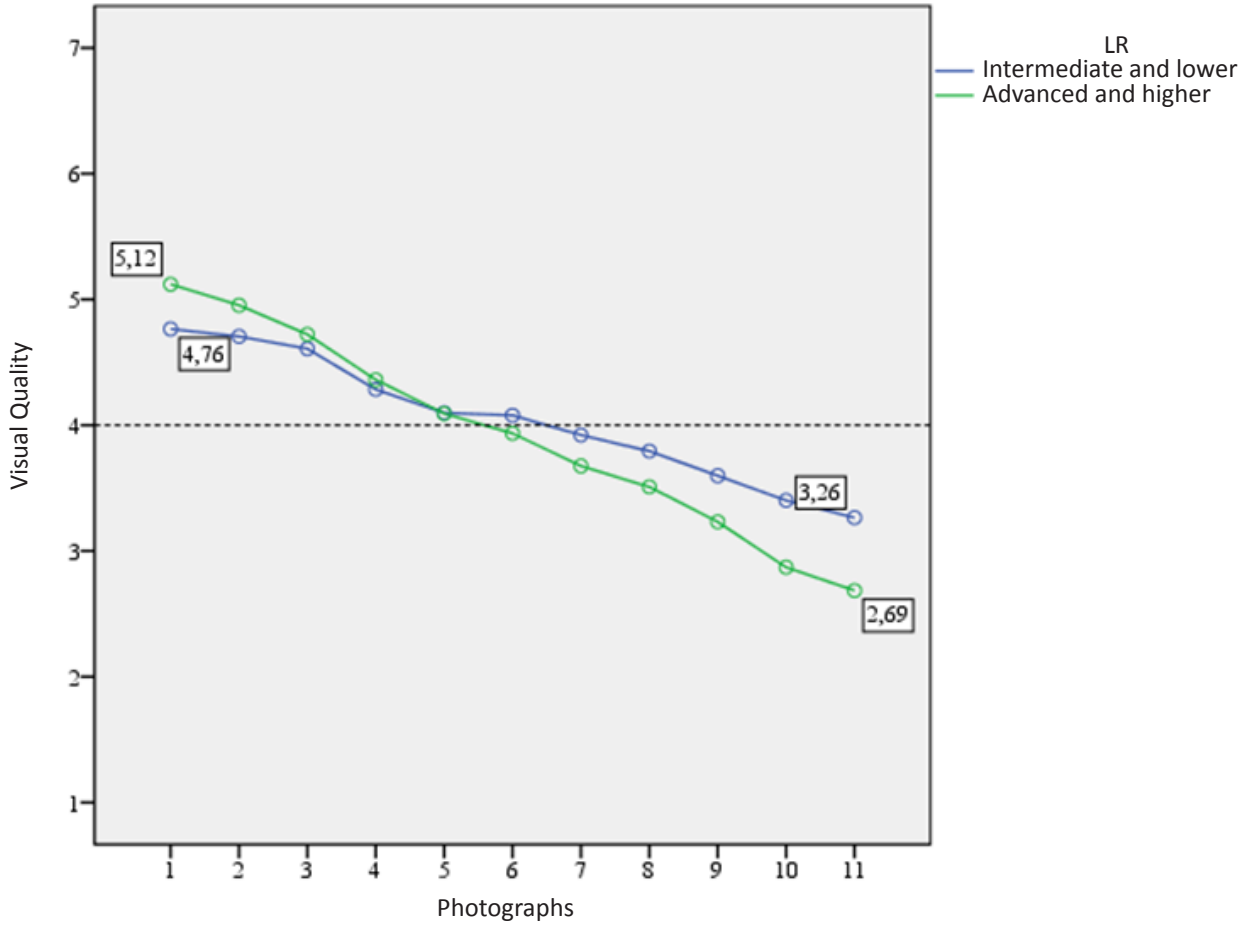

Figure 2. Curve of visual quality of participant according to climber proficiency on the basis of photographs (Chalk density effect)

Table 3. Results of Independent Group t-test conducted for determining if the perceived visual quality of participators changed according to the climbing level variable

Photo	Groups	N	Mean	Std. Deviation	t	df	p
Photo 1	Group I	102	4.76	1.70	-0.52	208	0.13
	Group II	108	5.12	1.69			
Photo 2	Group I	102	4.71	1.48	-0.22	208	0.23
	Group II	108	4.95	1.47			
Photo 3	Group I	102	4.61	1.46	-0.56	208	0.58
	Group II	108	4.72	1.50			
Photo 4	Group I	102	4.28	1.61	-0.35	208	0.73
	Group II	108	4.36	1.55			
Photo 5	Group I	102	4.10	1.77	0.02	208	0.98
	Group II	108	4.09	1.60			
Photo 6	Group I	102	4.08	1.86	0.59	208	0.55
	Group II	108	3.94	1.63			
Photo 7	Group I	102	3.92	1.90	0.99	208	0.32
	Group II	108	3.68	1.68			
Photo 8	Group I	102	3.79	1.90	1.14	208	0.26
	Group II	108	3.51	1.72			
Photo 9	Group I	102	3.60	2.00	1.41	208	0.16
	Group II	108	3.23	1.78			
Photo 10	Group I	102	3.40	2.03	1.97	208	0.05*
	Group II	108	2.87	1.89			
Photo 11	Group I	102	3.26	2.11	2.05	208	0.04*
	Group II	108	2.69	1.99			

Group I- Intermediate and lower; Group II- Advanced and higher

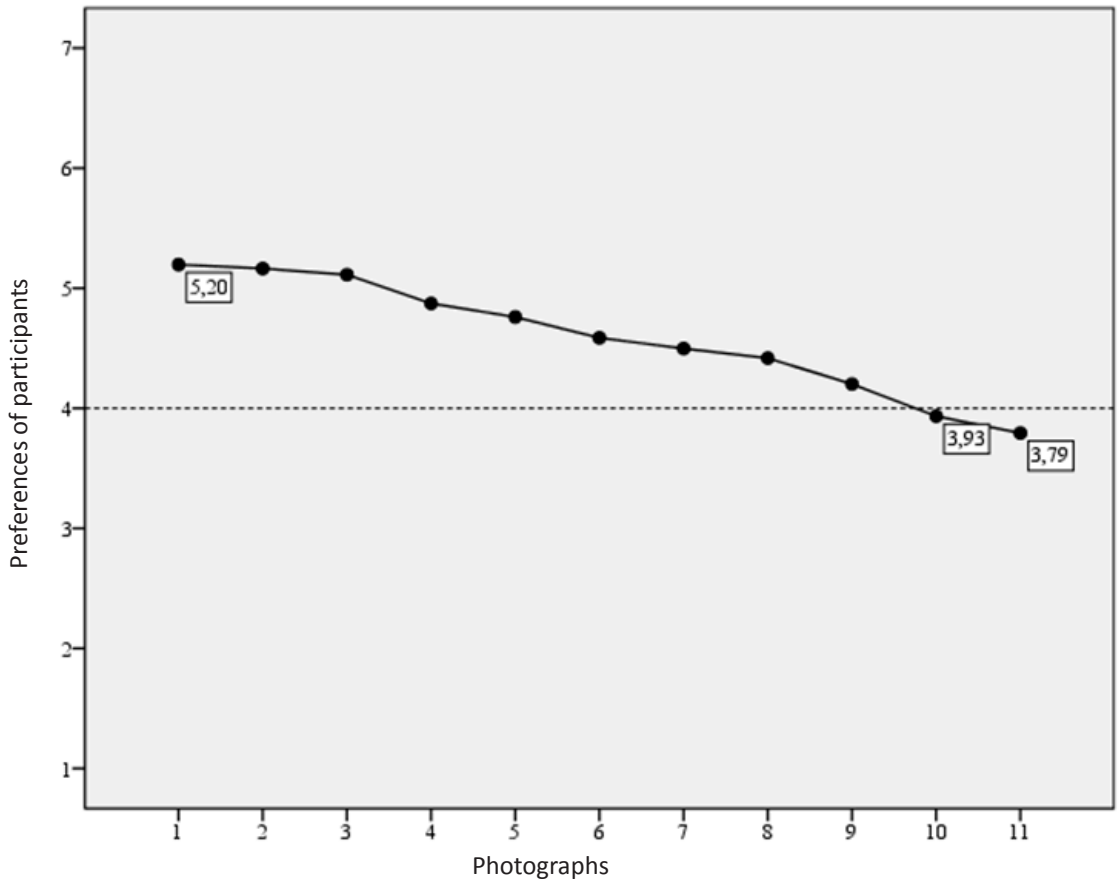

Figure 3. Participant climbing willingness curve on the basis of photographs (Chalk density effect)

about the willingness to climb (Intermediate and lower, advanced and higher) (see Figure 4). According to the paired comparisons, there are not statistically significant results between the two groups (p>.05).

Discussion

Rock climbing is a popular outdoor activity practiced in natural areas. Researching and analysing the impacts of activities based on nature and understanding visitor attitudes are significant for ensuring the sustainability of natural environments in these areas. Specifically reporting the effects of these activities on natural resources will give a direction to administrative norms and practices. Decreasing negative effects may, in turn, increase the number of visitors [19]. An increase in visitor experience and quality of experience significantly and directly affects

Table 4. ANOVA Comparisons of Visual Climbing Preferences of Participants on the basis of Chalk Effect

	Variables		Bonferroni Comparisons*										
	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1	5.20	1.67											
2	5.16	1.51	1.00										
3	5.11	1.48	1.00	1.00									
4	4.87	1.54	.19	.02	.00								
5	4.76	1.69	.06	.01	.00	1.00							
6	4.59	1.78	.00	.00	.00	.00	.00						
7	4.50	1.81	.00	.00	.00	.00	.00	1.00					
8	4.42	1.88	.00	.00	.00	.00	.00	.21	1.00				
9	4.20	1.92	.00	.00	.00	.00	.00	.00	.00	.00			
10	3.93	2.11	.00	.00	.00	.00	.00	.00	.00	.00	.00		
11	3.73	2.20	.00	.00	.00	.00	.00	.00	.00	.00	.00	.03	

*p-value

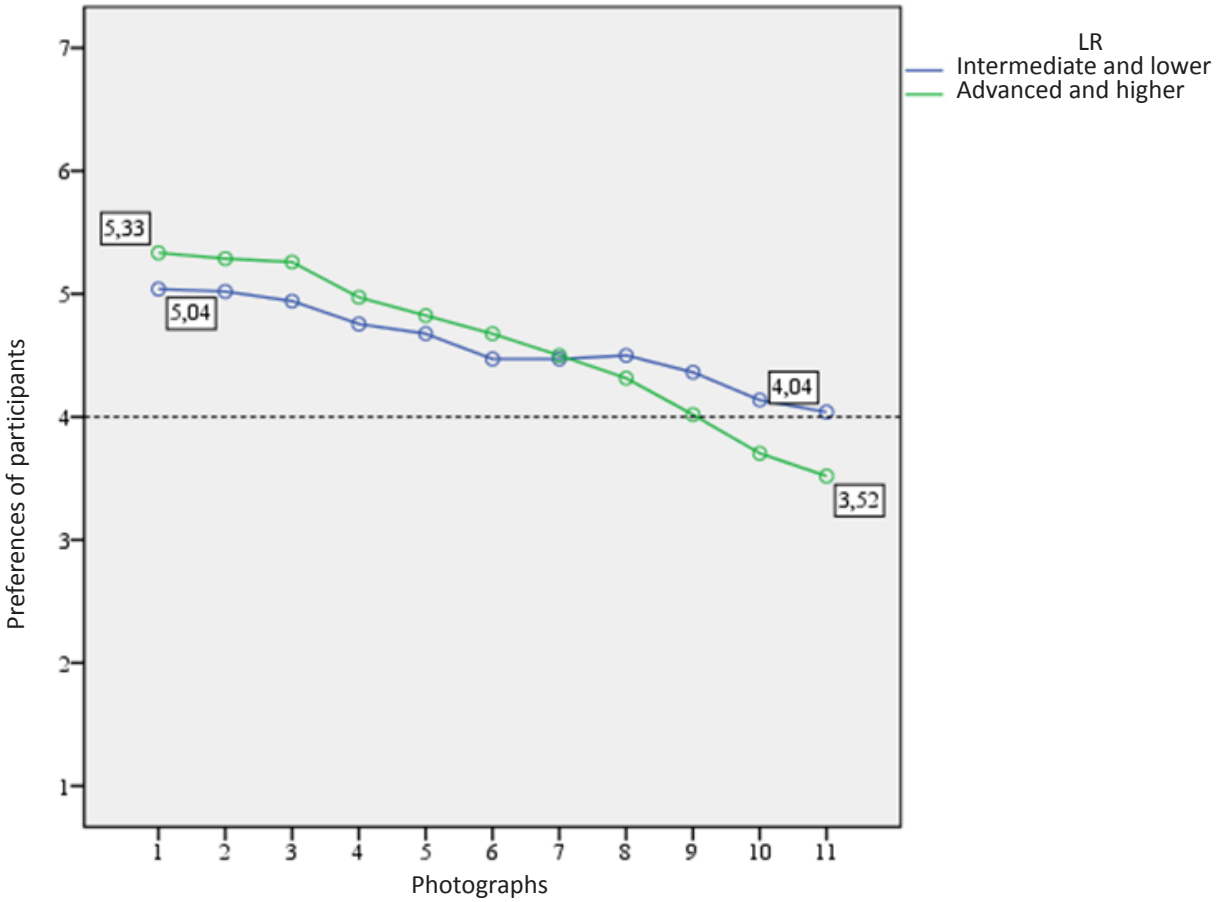

Figure 4. Curve of climbing willingness of participant according to climber proficiency on the basis of photographs (Chalk density effect)

Table 5. Results of Independent Group t-test conducted for determining if the climbing willingness of participators changed according to the climbing level variable

Photo	Groups	N	Mean	Std. Deviation	t	df	p
Photo 1	Group I	102	5.04	1.69	-1.28	208.00	0.20
	Group II	108	5.33	1.65			
Photo 2	Group I	102	5.02	1.58	-1.29	208.00	0.20
	Group II	108	5.29	1.42			
Photo 3	Group I	102	4.94	1.53	-1.57	208.00	0.12
	Group II	108	5.26	1.40			
Photo 4	Group I	102	4.75	1.59	-1.02	208.00	0.31
	Group II	108	4.97	1.49			
Photo 5	Group I	102	4.68	1.78	-0.63	208.00	0.53
	Group II	108	4.82	1.60			
Photo 6	Group I	102	4.47	1.86	-0.84	208.00	0.40
	Group II	108	4.68	1.70			
Photo 7	Group I	102	4.47	1.90	-0.12	208.00	0.91
	Group II	108	4.50	1.72			
Photo 8	Group I	102	4.50	1.93	0.72	208.00	0.48
	Group II	108	4.31	1.82			
Photo 9	Group I	102	4.36	1.98	1.27	208.00	0.21
	Group II	108	4.02	1.96			
Photo 10	Group I	102	4.14	2.07	1.49	208.00	0.14
	Group II	108	3.70	2.13			
Photo 11	Group I	102	4.04	2.13	1.72	208.00	0.09
	Group II	108	3.52	2.24			

Group I- Intermediate and lower; Group II- Advanced and higher

perceived value and satisfaction. Previous studies indicate that an increase in perceived value and satisfaction has positive effects on loyalty and the possibility to revisit the place [34]. Qualities of routes and purity of the natural environment are the other important factors that affect the motivation of climbers [35]. This is why insufficient precautions and the negative impacts of visitors on nature and climbing routes will naturally have negative impacts on visitor/climber experiences. In the visual preference study, carried out by Jones [12] in Rock Canyon, 16 photographs were used to determine the ideas of 143 participants. According to the study, participants had more positive views about the photographs in which there are no bolts. On the other hand, according to the results of the very same study, chalk use didn't have any statistically significant visual impact. In the study by Waldrup and McEwen [36] in Red Rock Canyon, it was determined that climbers didn't find the use of bolt and chalk irritating; field administrators and other visitors defined these two factors as 'problems'. According to the results of this study, an increase in the use density of chalk on rocks decreases the perceived visual quality and climbing willingness of climbers. In this respect, it is determined that the density of chalk, namely the amount of use, has a negative impact on perceived visual quality; it is important to note that the negative effect isn't caused by just the use of chalk. An increase in the proficiency of climbers increases their dependency on resources and decreases their sensitivity about the effects they personally have on nature [37]. In the frame of this information, the effects of the experience and proficiency level of participants on their perceived visual quality and climbing willingness on the basis of the chalk density on rocks, are analyzed. At the end of the study, it is found that their experience didn't affect the perceived visual quality and climbing willingness, while their climbing proficiency affected perceived visual quality and climbing willingness. An increase in chalk density on climbing routes decreased advanced and higher-level climbers' perceived visual quality and willingness. The climbing willingness of participants with high proficiency changed from positive to negative specifically in the photographs with high levels of chalk use (photographs 10 and 11). On the other hand, while climbing willingness of participants with intermediate and lower climbing proficiency decreased, they didn't have a negative climbing willingness even in the photograph with the highest level of chalk use. This result is contrary to the idea that the increase in the proficiency of climbers decreases their environmental sensibility [37]. This contradiction in the two views might be the result of the samples in these studies. While the sampling of the other study is defined as "climbers" in general, this study is specifically practiced with sports climbers. At this point, it is important to note that the definition of climber can be used for mountaineers and rock climbers. Additionally, the expression of a rock climber can be divided into two

types as traditional climbers and sports climbers; these two groups have different approaches and practices [37]. Analysing the differences between traditional and sports climbers in future studies can make significant contributions to the literature.

As a result, besides the negative visual impact of the use of material, an increase in the density/amount of it may negatively affect the climbing willingness of climbers. It is generally considered that negative results of outdoor recreations are inevitable results [38]; however, direction and dimension of these impacts are closely connected to the visitor behaviours and administrative approaches in the area. Within this scope, to ensure the sustainability of natural environments, it is necessary to make plans for preventing and reducing the negative effects and informing visitors on the basis of these plans. It is known that while climbers have the tendency to give importance to natural life and environment, they don't generally support the existence of official authorities in these fields [19]. Recreations and field managers should improve administrative activities and they should cooperate with users like rock climbers to minimize the negative effects of outdoor activities, protect natural resources and increase the quality of recreation experiences [39]. In this context, it is believed that informing climbers about the negative effects of chalk use level, directing them towards the use of materials that will leave less serious marks on climbing routes (coloured chalk, liquid chalk, etc.) or suggesting them clean the route with brush after climbing can decrease the negative impacts of these activities on nature. On the other hand, it is suggested that routes that are commonly used by climbers are cleaned by workers appointed by field managers.

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Conflict of interest
The authors declare that there is no conflict of interests.

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ORIGINAL ARTICLE

Time-Motion analysis of the 2017 Wrestling World Championships

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Authors' contributions: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Purpose: The purpose of this study was to determine the relative contribution of energy systems in a freestyle (FS) and a Greco-Roman (GR) wrestling match, quantity and quality of obtained scores, and the competition efficiency of winners in the 2017 Wrestling World Championships (WCh) through analysing the recorded videos of all the matches of this event.

Material: The materials of the present study were 295 FS and 266 GR recorded videos of the 2017 WCh, a multimedia player (lap top) for watching and analysing them, and a chronometer for recording the different duration of activities happening during these matches. In addition, special papers were designed in advance to make sure that all the required data were recorded properly.

Results: The percentages of ATP-PC (ATP), lactic (LAC), and aerobic (AERO) energy systems were 6.66, 62.74, and 30.60 in FS, and 5.94, 67.53, and 26.53 in GR. Quantity and quality analysis of scores showed that FS wrestlers significantly scored more 1- and 4-point, while GR wrestlers were superior regarding the quality 2-point. The average competition efficiency of gold medallists was 18/43±4/67 in FS and 15/87±3/18 in GR which were statistically significantly greater than that of all other placers.

Conclusions: This study showed the dominance of LAC in a wrestling match in both styles, although their relative contribution was significantly different between styles. In addition, FS wrestlers significantly scored more points, and Gold medallists demonstrated the greatest average competition efficiency compared to other medallists.

Keywords: wrestling, energy systems, scores, competition efficiency

Introduction

It is a fact that the Olympic Games and world championships (WCh), with the best athletes from all over the world participating in them, represent the highest quality of sports. Although it is hard to make these championships measurable, time-motion analysis has been used in different kind of sports to provide accurate data of sport events and the movement patterns and activity profiles during a match [1]. These data help coaches better understand their specific sport, investigate the technical and tactical behaviours of top athletes, and even investigate their the physiological and metabolic demands of their sport major [2, 3]. Besides, time-motion analysis provide them with the chance of comparing their athletes with the best in the world [4]. Thus, the information derived from time-motion analysis will assist coaches to develop more effective sport-specific training programs [5].

Wrestling as one of the oldest sports of all times has been done in modern Olympics since 1986 in both freestyle (FS) and Greco-Roman (GR) by men, and women's freestyle (WFS) was also introduced to these games in 2004 [6]. Each of these styles has its own rules and regulations which make them to be viewed as different combat sports [7]. And, this has been of considerable interest by some researchers who tried to further investigate the dissimilarities between these two styles (GR and FS) and also between the physical characteristics of the athletes in each style. For instance, in a study by Mirzaei et al., they showed that Iranian GR wrestlers significantly obtained better results in Wingate tests, hand grip, chess press, and dead lift, while $VO2_{max}$ and upper back strength were significantly higher in FS wrestlers [8]. An additional example is the study of Baic et. al., where they demonstrated that FS wrestlers' strength endurance of trunk and upper extremities was statistically significantly more than that of GR wrestlers [9].

There is a considerable amount of information in the sport science literature regarding the relative contribution of three energy systems, namely anaerobic alactic/ATP-PC (ATP), anaerobic lactic (LAC), and aerobic (AERO) mainly because it is a key factor in designing and implementing sport-specific and conditioning programs. Thus, understanding how each of these energy systems works and applies to sport training, and which of them is the dominant one in a certain sport are vital requirements for coaches and instructors [10]. ATP provides energy for explosive and short duration sporting actions taking up to 10 seconds, LAC is responsible for producing energy for actions of relatively longer duration, 15 to 60 seconds, and AERO is employed to produce energy in sports ranging from one minute to more than three hours [10, 11]. However, while, with this description of energy systems, it seems easy to determine where a sport major falls in the continuum of energy systems contribution, it requires an especial consideration when considering a sport with intermittent nature, for example, wrestling, boxing, team sports, mixed martial arts, and so on. More specifically, in the active part of these sports energy is produced by anaerobic pathways (ATP and LAC), whereas

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they strongly rely on aerobic energy system during the short recovery periods between actions [10]. To the best of our knowledge, the only study which determined the relative contribution of the energy systems in wrestling is an investigation conducted by Mirzaei et al., in which they also showed that there were significant differences between GR and FS in the employment percentage of each energy system [12].

Another advantage of time-motion analysis is scoring analysis which leads to a better understanding of winners' competition efficiency, attack and defence efficacy, obtained scores, common used techniques, etc. These information deliver important benefits to coaches in order to incorporate this knowledge into their training routines and improve their athletes' technical and tactical acquisition [13]. For instance, Mirzaei et al., showed that FS wrestlers generally scored more points than what GR wrestlers did in the 2015 WCh, and the total number of 1- and 2-point scores was grater in FS while that of 4- and 5-point scores was greater in GR [12]. It is also noteworthy to mention that all these technical and tactical variables are significantly influenced by rule changes which usually happen after each Olympic Games [12]. A clear example of the impact of these changes can be seen in a long-term analysis of world and Olympic championships by Tunnemann [3]. He showed that the number of technical points scored per minute had a clear downtrend since 2005, and then it hit a bottom in the 2012 Olympic Games, where it was even possible to get a win by a totally defensive strategy, but after the 2013 rule changes there was a considerable increase in the number of points scored per minute [3].

Therefore, the objectives of this study were 1) to determine the relative contribution of energy systems in a single wrestling match of the 2017 WCh, 2) to determine the total quantity and quality of obtained scores in FS and GR in the 2017 WCh, 3) to determine the competition efficiency of the 2017 WCh medallists, 4) to compare the mentioned variables (1, 2, and 3) between GR and FS to further investigate these styles' differences, and 5) to demonstrate the impact of the rule changes after the 2016 Rio Olympic Games on these variables (1, 2, and 3).

Material and Methods

Sources of information.

The videos of all matches of the 2017 wrestling WCh (295 and 266 videos in GR and FS respectively), which were posted on the UWW website, a multimedia player (lap top) to watch and analyze the videos, and a chronometer to record the duration of activities during wrestling matches were the materials of the present study. In order to make sure that all the desired data were recorded properly, especial papers were designed, and all the data were noted in its specific section.

Research Design.

Each video was analyzed two times. During the first analysis weight classes (FS: 57,61, 65, 70, 74, 86, 97, 125; GR: 59, 66, 71, 75, 80, 85, 98, 130), whole duration of a match (from start to the end), legal time that is two 3 minutes with 30 seconds rest between, quick and explosive movements (all the performed techniques, and fast movements of both legs and hands), and duration of vigorous activities that is the active part of a match when wrestlers are struggling were recorded. During the second analysis competition efficiency of winners who were gold medallist (GOLD), silver medallist (SILVER), and the two bronze medallists (BROMZE 1 and 2 who lost to GOLD and SILVER respectively) was recorded. With respect to competition efficiency, +1, 0, and -1 were respectively given to the actions resulted in point, no point, or point loss, and the sum of them was considered as the athletes' competition efficiency. Finally, the scores quality (percentage of 1-, 2-, 4-, and 5-piont) and quantity (number of 1-, 2-, 4- or 5-point) separately in FS and GR were recorded.

As the relative contribution of energy systems directly depend on the intensity and duration of sporting actions, recorded durations of difference activities happening in a wrestling match were used to determine the relative contribution of three energy systems: to determine the relative contribution of ATP-PC energy system (ATP), all the explosive actions were recorded. Then each of them was counted as one second as Blais et al. showed that performing a technique in combat sports can be as short as 1 second [14]. And, the sum of them was considered as the total time of this energy system. This time was subtracted from the time of vigorous activities and the remained seconds were counted as the time of lactic acid energy system (LAC). This subtraction was done as the explosive actions had happened within the time of vigorous activities. Finally, the time when wrestlers were not in contact, such as breaks between periods and points, video check and injury time-outs, and any other time when wrestlers were not in contact was devoted to aerobic energy system (AERO). For this purpose, we subtracted the time of vigorous activities from the whole duration of a match. Finally, the time ratio of each energy systems to the whole duration of a match revealed the relative contribution of each energy system.

Statistical analysis.

Descriptive statistics (mean and standard deviation) in form of tables and graphs was used to describe and explain data, and inferential statistics (Kruskal-Wallis H and Mann-Whitney U with a significantly level of $p<0.05$) was used to determine the differences between FS and GR, and the competition efficiency of placers. In addition, the normality distribution of data was tested using the Kolmogorov-Smirnov Test. The software used for drawing the graphs and analysing data were Excel and version 22 of SPSS respectively.

Results

The average of the whole duration and the legal time of a wrestling match in different styles of the 2017 WCh is represented in Table 1, and the comparison between these two styles showed a significant difference in the legal time ($p<0.05$). More specifically, the FS matches took shorter than the matches in GR.

Table 1. The average of the whole duration and the legal time of a GR and a FS match in the 2017 WCh (minute)

Styles	Whole duration	Legal time
Greco-Roman	7.43±2.08	5.41±1.36*
Freestyle	7.34±2.49	5.02±1.08

* - shows the significant difference between GR and FS ($p < 0.05$)

Figures 1 and 2 show the relative contribution of energy systems in a GR and a FS match, respectively. The comparison between these styles demonstrated that ATP and AERO were significantly more employed in FS ($p<0.05$), while LAC employment showed to be significantly higher in GR ($p<0.05$).

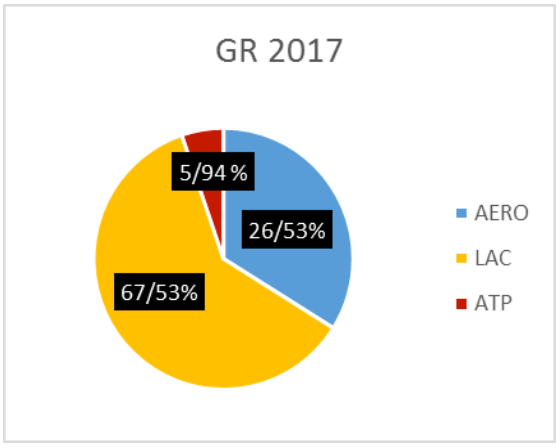

Figure 1. Relative contribution of energy systems in a GR match of the 2017 WCh (percent)

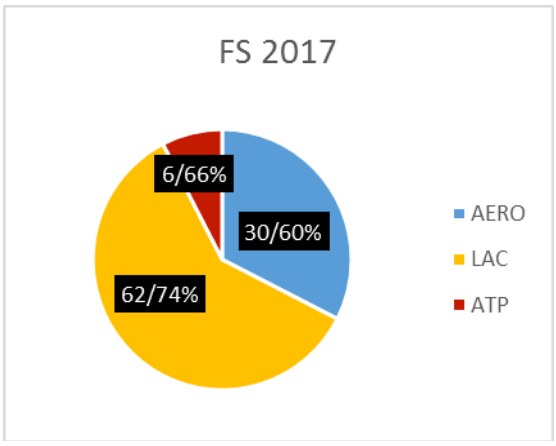

Figure 2. Relative contribution of energy systems in a FS match of the 2017 WCh (percent)

The obtained scores are presented in both quantity and quality in Table 2. The comparison of the quantity demonstrated that FS wrestlers significantly scored more 1- and 4-point than GR wrestlers, and the quality comparison showed a significant difference in 2-point percentage, which was higher in GR ($p<0.05$).

The average competition efficiency of placers is presented in the following table (Table 3). In general, GOLDs had the highest values in both styles, which were significantly higher than that of other placers ($p<0.05$). Besides, SILVERs showed to have the second highest values, which were higher than both bronze medallists, but only statistically significantly higher than BRONZE 2 ($p<0.05$). Although the competition efficiency of BRONZE 1 was higher than BRONZE 2, there was no significant difference between them ($p<0.05$).

Table 2. Quantity (number) and quality (percent) of the obtained scores in GR and FS in the 2017 WCh

Styles	Criterion	1-point	2-point	4-point	5-point
Greco-Roman	Quantity	361	567	102	2
	Quality	34/02	55/70*	10/08	0/18
Freestyle	Quantity	505*	755	279*	0
	Quality	33/78	47/98	18/12	0

* - shows the significant difference between GR and FS ($p < 0.05$)

Table 3. The average of placers' competition efficiency in the 2017 WCh (point)

Styles	GOLD	SILVER	BRONZE 1	BRONZE 2
Greco-Roman	15/87±3/18	10/87±4/05*	8/25±3/53*	6/87±1/55*†
Freestyle	18/43±4/67	12/93±4/05*	10/12±4/54*	7/31±2/27*†

* - shows the significant difference between GOLD and other placers, † - shows the significant difference between SILVER and BRONZE 1 and 2, and shows the significant difference between BRONZE 1 and 2 ($p < 0.05$)

Discussion

The present study was carried out to find answers of aforementioned five questions, and the obtained results are going to be discussed in this section. The first finding of this study was the average value of the whole duration and the legal time of a wrestling match which is represented in Table 1. The whole duration of a match includes the time from start to end of it, and the legal time is now two 3 minutes with 30 seconds rest between. The latter could take shorter under four conditions, including technical superiority (a difference greater than 8 points in GR and 10 points in FS), victory by fall, injury, and/or disqualification of one of the wrestlers [12]. The result of this study showed a significant difference between GR and FS regarding the legal time which illustrated that in general FS matches took shorter than GR ones (FS: 5.02±1.08 vs. GR: 5.41±1.36). This could be because of the higher number of points scored in FS, as a result more matches ended with technical superiority. However, in the same analysis of the 2015 WCh by Mirzaei et. al., they showed that the whole duration of GR matches was significantly longer than that of FS (GR: 7.33±2.97 vs. FS: 6.58±2.71), and there was no significant difference in the legal time between them (GR: 4.86±1.70 vs. FS: 4.75±1.79) [12]. They explained that the reason for this difference was the GR rules as referees used to give passive cautions to passive wrestlers by repeatedly stopping the match, resulting in a longer whole duration [12]. This rule was eliminated after the 2016 Rio Olympic Games [12]. Yet, this cannot explain the result of the present study which did not show a significant difference between the styles regarding the whole duration. Although the mentioned rule was no longer existed in the 2017 WCh, the whole duration of the GR matches did not show any decrease, and actually it was the increase in the whole duration of the FS matches which almost equalled that of GR and was responsible for no significant difference between them. In conclusion of this section, the whole duration and the legal time of a wrestling match is significantly different between the GR and FS, and these values could be affected by the rule changes happening after each Olympic Games.

Another major finding of the present study was estimation of the energy systems' relative contribution that is the base element for designing an effective conditioning program. And, it was carried out through measuring and recording the activities with different modes, intensities, and durations during a single wrestling match. The obtained result showed that the anaerobic lactic energy system predominates a wrestling match with a value of 67.53% and 62.74% in Greco-Roman and Freestyle respectively (Figure 1 and 2). It has been mentioned in the literature that wrestling is anaerobic in nature [6, 12, 15]. Moreover, Bompa supposed that anaerobic energy systems together are responsible for providing around 60% of the energy cost in wrestling [10], and Fukuda et al., said that anaerobic power and capacity are the primary elements for success in wrestling [16]. All these are in accordance with our findings. Still, the contribution of the energy systems in wrestling was not quantified until Mirzaei et. al. analyzed the 2015 WCh and determined the proportion of each energy transfer system in a wrestling match [12]. After LAC, having the greatest contribution, aerobic and anaerobic alactic energy systems have the second and third greatest values with 26.53% and 5.94% in GR and 30.60% and 6.66% in FS respectively. The same order but not the same percentages was also shown by Mirzaei et al. [12]. However, while the priority of these three energy systems are in the same order in both styles, further investigations showed significant differences between GR and FS regarding the employed percentage of each of them. More specifically, the employment of LAC was significantly greater in GR which is an indication of these wrestlers' constant effort especially in the stand position. This could be due to two reasons. First, passive cautions are given to GR wrestlers as the match continues, and second, a smaller number of points scored in GR means less interval rest between them. On the other hand, ATP and AERO showed to be significantly larger in FS wrestling. Of note, ATP produces energy for the quick and explosive actions that are decisive in this sport because the obtained scores are the result of these actions; besides, as it was already mentioned, after scoring a point there is a short period of pause that uses AERO in order to recover the energy sources, creatinine phosphate in particular [17]. Therefore, the higher relative contribution of these two energy systems is clearly due to the higher number of points scored by wrestlers in this style. So, it could be concluded that putting an effort to gain a point not only exhausts one and decreases the quality of their performance but also rewards them by a period of active rest which even help them to be more active and gain more points. In another study by Campos et al., they investigated the energy systems contribution and energy costs during a taekwondo combat [17]. Their method consisted of measurement of oxygen consumption, the fast component of excess post-exercise oxygen consumption, and the change in blood lactate concentration in order to estimate the contribution of AERO, ATP, and LAC energy systems, respectively [17]. They showed that during a taekwondo match energy was provided 66±6% by AERO, 30±6% by ATP, and only 4±2% by LAC, which showed the total predominance of the aerobic energy system in this sport [17]. The difference between their findings and the result of the present study could be attributed to the fact that in taekwondo athletes are not in contact, and they approach each other only when they want to strike a kick or a punch, whereas in wrestling athletes are in direct contact for almost the whole legal time (6 minutes). Besides, wrestlers have to bend their knees and body, bear their own body weight, and tolerate the pressure exerted by their opponent, who attempts to push them out of the mat or throw them off balance. The powerful contractions, isometric and quasi-isometric ones in particular, happening in these situations cause blood vessels occlusions within the contracted muscles, as a result, oxygen cannot be delivered to the cells and metabolite by-products cannot be removed [18]. Thus, the energy production shifts from aerobic to anaerobic. To sum up, the sport of wrestling

either in GR or FS is anaerobic in nature. Even though the order of energy systems is the same in both styles, there are significant differences between them regarding the energy systems' relative contribution, and rule changes could influence these proportions.

In addition to the mentioned findings, investigating the total quantity and quality of obtained scores in both styles is another main outcome of the present study. As you can see in Table 2, the total quantity of 1-, 2-, and 4-points are clearly greater in FS with the exception of 5-point being greater in GR. And, two of these differences that are 1- and 4-point are significant. Furthermore, compared to the GR result of the 2015 WCh, 1-point shows 6 number increase, while there are decreases with the magnitudes of 123, 61, and 1 regarding 2-, 4-, and 5-point respectively [12]. This shows that the upward trend in number of points seen by Tunnemann (2016) after the 2013 rule changes experienced a considerable reduction when the 2016 rule changes was applied to this style [3]. This could negatively affect the attractiveness of this style. On the other hand, compared to the 2015 FS WCh, the result of the 2017 FS WCh showed quantity increases in 1- and 4-points with the magnitudes of 5 and 169 respectively, while that of 2-point decreased by 331 numbers. And, the quantity of 5-point was 0 in both championships. This greater number of scores in FS could be attributed to the fact that techniques targeting both upper and lower body are allowed in FS while GR involves only techniques at the upper body [16]. We calculated the total sum of points (sum of the quantity of each point multiplied by its value [1, 2, 4, and 5]) in both years to better understand the difference between them. And, the result (2015: 3112 vs. 2017: 3131) showed a negligible rise of 19 points in the 2017 FS WCh. However, the more important finding of this comparison was the substantial growth of 4-point techniques which are the most important element of the attractiveness of this sport. Additionally, the quality of the scores was in the same order in both styles with 2-point being the greatest and then 1-, 4-, and 5-points being the next ones respectively. The only significant difference in this regard was the quality of 2-point which showed to be greater in GR. This is in the contrast with the result of Mirzaei et al., who showed that the percentage of 2-point was greater in FS, and that of 4-point was greater in GR in the 2015 WCh [12]. Again, this shows that the attractiveness of GR is reducing whereas it is improving in FS. Like other findings of the present study, GR and FS showed to be different in these variables as well, and the 2016 rule changes had a significant impact on them.

The final finding of the present study is the average competition efficiency of the winners in both GR and FS (Table 3). The result showed that the gold medallists of both styles statistically significantly had the greatest competition efficiency compared to other placers. In addition, the second greatest values belonged to the silver medallists, and there were significantly more than that of BRONZE 2. However, there were no significant difference between BRONZE 1 and 2, even though the competition efficiency of BRONZE 1 was higher. In the study of Mirzaei et al., they showed that the average competition efficiency of gold, silver, bronze 1 and 2 medallists was 12±3.38, 6.12±2.29, 7.5±3.07, and 9.37±4.34 in GR and 17.87±4.70, 12.75±2.54, 14.62±8.70, and 12±5.52 in FS, respectively [12]. They have only compared GOLD to other placers and showed that in GR it was significantly greater that SILVER and BRONZE 1, while in FS it was only greater than that of SILVER but not bronze winners [12]. As you can see, the values resulted from their study were not in a logical order. Actually, the values of bronze medallists have appeared to be greater than SILVER and had no significant difference with GOLD. However, in the present study as the rank of placers decreased so did their competition efficiency. This could be attributed to the seeding system that was applied to the 2017 WCh for the first time in the history of this sport. According to this system, top four seeds were determined by the points awarded to wrestlers who competed in the 2016 Olympic Games, 2016 non-Olympic weight classes World Championships, and the 2017 Continental Championships [19]. Then they were separated in order to guarantee premier semifinal and final matchups [19]. Thus, top wrestlers were given the chance of competing lower rank athletes, and this might be the reason of their competition efficiency improvement especially in GR.

Another advantage of this system is that all the top athletes have the chance of winning a medal which was not possible before as there was a possibility that all four top wrestlers be in the same half of the table. In another study by Tunnemann and Curby, which was an investigation of the 2016 Olympic games, they showed that not only the athletes who had a better attack ability obtained a better result but also there was a good balance between the attack and defence abilities of the wrestlers from top nations, such as Azerbaijan, Iran, Russia, and Japan [20]. The difference between GR and FS is also clear in this variable, and also the effect of the application of the new rules.

Conclusion

The present study determined the average time of which a GR and a FS match takes from start to end as well as the actual duration of the legal time of both styles. In addition, there were significant differences between Greco-Roman and Freestyle regarding the relative contribution of energy systems. However, the glycolytic energy system was the dominance one in a single wrestling match in both styles. The quantity of the obtained scores in Greco-Roman style experienced a substantial reduction, while in Freestyle the number of points showed a considerable increase and most of it was as the result of the rise in 4-point scores. Furthermore, it seems that seeding system had a positive effect on the competition efficiency of the placers. Additionally, it must be mentioned that the 2017 WCh was analyzed by the same method that was used by Mirzaei et al. (2017), to analyze the 2015 WCh. This makes our comparisons more reliable. Moreover, the level of the 2015 and 2017 Wrestling World Championships could be different

due to the fact that the 2015 WCh was the year before Olympic Games when wrestlers try to become qualified for participation in these games and confront their best opponents; on the other hand, in the year after the Olympic Games, top wrestlers may prefer not to participate in the world championships. Finally, all the measured variables in this study showed to be significantly different between the GR and FS, and the difference between the 2015 and the 2017 WChs indicated the impact of rule changes after the Olympic Games.

Conflict of interests

The authors declare no conflict of interests.

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ORIGINAL ARTICLE

The effect of six weeks CoBAgi training on coordination, dynamic balance & agility of adolescent handball players

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: The aim of this study is to investigate the effects CoBAgi Training which apply neuromuscular training, sport specific movements that couple with perturbation variation on coordination, dynamic balance and agility among adolescent handball players.

Material: Quantitative randomized controlled trials quasi-experimental design with pretest and posttest evaluation used for this study. A total of 30 adolescent handball players (aged: 14.00 ± 0.83 years) were recruited as participants. Purposive sampling methods were used for these purposes. The participants were randomly assigned into two groups i.e. control group (CG: n=15) and experimental group (EG: n=15). EG undergone six weeks CoBAgi training while CG followed their usual training routine with supervision of the researcher, there times a week for 6 weeks. In order to measure the effect of these training on coordination, dynamic balance and agility, participants have performed Carioca Test, Star Excursion Balance Test (SEBT) and L-Run Test during pre-training and post-training session. The data were analyzed through Independent Samples t-test with $p<0.05$ "Statistical Package for the Social Sciences" (SPSS) program.

Results: After completed the six weeks training duration, there were significant difference identified in coordination (t=-2.290, P=0.030*), dynamic balance (t= 4.802, P=0.000*) and agility (t=-3.202, P= 0.003*) between EG and CG.

Conclusions: Therefore, this study revealed that CoBAgi training could improve abilities performance of coordination, dynamic balance and agility, and this suggesting that CoBAgi training may be use as rehabilitation and pre-rehabilitation training strategies in order for injury prevention plan as well as improve sports performance especially among the adolescent handball players.

Keywords: dynamic balance, coordination, agility, perturbation, pre-rehabilitation, handball

Introduction

Handball is one of the fastest team sports where this game requires high physical fitness level [1] i.e. power, speed, agility, endurance, balance, flexibility, accuracy and coordination. Undoubtedly, handball player is multitasker where he/she is a jumper, thrower and sprinter, requires good joint accelerations for landings, jumping and cutting manoeuvres. This game is physically demanding, accelerative, decelerate and intermittent in nature [2]. It also involves high degree of contact and studies revealed that record of injuries in handball sustained for every 1,000 playing hours ranging between 2.5 to 108 injuries [3]. This showed that handball players are prone to injury. Since 1999, handball rules amendments occurred and resulted with limitation for attack duration (the passive play), and converted the nature of the game to be faster [4]. Apart from that, acute and overuse injuries among adolescent have raised up in return of weakness in motor skills adaptation [5]. Thus, involvement of adolescents is handball would risk them with sport injuries.

Besides collision, individual factors would cause injuries such landing from a jump or cutting movement and, actually, with no body collision [6]. Facts reported that 115 of anterior cruciate ligament injury case in two studies i.e. 95% male and 89% female players got injured without player-to-player contact [6]. Also, 85% of the anterior cruciate ligament injuries resulted from indirect contact or non-contact mechanisms [7]. These may be the result of sudden deceleration affected by change of direction or landing motion. For that player, especially adolescent should own a great proficiency of physical and technical abilities that can be train by manipulating some modifiable factors. Coordination, fitness level, flexibility, participation in sport-specific training, proprioception and strength are some of the modifiable elements [5]. Deficiency of these is the main contributor for non-contact injuries occurrence.

To avoid the injuries and perform well, good skills execution is needed and require excellent coordination, dynamic balance and agility interpretation. Balance shows relationship between coordination and agility. Balance is the main components of coordinative abilities which need for complex sport movements and protection against the injuries [8]. As well, enhance body balance control in positions should improve agility [9]. All the positive outcome will only be success thru manipulating the right training method with modifiable factors because such method was reported effective in sports setting [10]. In fact, these supports the need of limitless substitution number practice in handball that demands the reinforcement to design high intensity, short-duration and short-time recovery exercises such jumps, repeated sprints, contacts

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and pulling/drift actions for both conditioning and mixed (tactical and physical-based) training sessions [4]. Considering the effects of significant facts as mentioned above, the modifying of some training elements could have beneficial effects on adolescent handball players.

Numerous studies have stated that performance of the players has been improved through several training methods such as resistance training [11], neuromuscular training [12] and sport-specific training [11]. Also, there was a study that reported performance improvement through perturbation training [10]. However, some studies using combination training program in handball players on risk factors for injuries such as forward sprint-jump and vertical jump. It was reported the result of perturbation-based training led to a greater reduction in frequency of multi-step reactions and foot collisions in older adult [13]. Finding has highlighted the positive outcome for perturbation where this could be beneficial if being implement for healthy athletic community as preventive program. Perturbation simply understand as incidents that change a system state from a stable (invariant) to an unstable (variant) situation or vice versa. However, many studies only focus perturbation training on balance and proprioception for patients and there is little demonstrate its potential in a healthy, athletic population. Indeed, there is also lack of research in prevention injuries in handball. Therefore, further studies are needed to investigate the effects of combination training including perturbation training on performance.

Like mentioned before, relationship between coordination, dynamic balance and agility will play a significant impact on sports performance. The main role is contributing from balance ability which mean, improvement on it will improve coordination and agility as well. Thus, modification of training such multifaceted intervention would bring effective result [14]. With those mentioned facts, present study designed a training known as Coordination, Dynamic Balance and Agility (CoBAgi) Training on foundation with combination between specific sport skills, neuromuscular training and perturbation training. Hereby, it was hypothesized that CoBAgi Training could improve the performance of coordination, dynamic balance and agility which in return reduce the injury risk. Thus, this study aimed to investigate the effect of CoBAgi training among adolescence handball players for injury prevention.

Material and Methods

Participants

A total of 30 adolescence handball players of SMK Lahat enrolled in this study. The players average age, height and weight displayed as in table 1.

Research Design

This is a quasi-experimental study with pretest and posttest evaluation involving 30 voluntary enrolled adolescence handball players, ranging from 13 to 15 years old from SMK Lahat. They were divided into experimental and control groups through random sampling method. To be selected in this study, participants need to be healthy and with at least one year free from injuries. They were excluded if they were identified with recurrent injuries or got injury during implementation of study.

Before admission to this study, participants and their parents/guardian were briefed with the study purposes, benefits, risk and parents/guardian signed the informed consents, as agreement proof for their children participation.

Participants answered screening form to make sure that only players with no injuries or free from injuries with at least one year being selected. Three testing instruments used to identify three components which are dynamic balance, coordination and agility. Participants were tested prior the intervention, and tested again after completed the intervention.

Score of pretest and posttest being compared to identify the different. Star Excursion Balance test (SEBT) was used to access dynamic balance, Carioca Test was used to access coordination and L-Run Test was used to access agility. Training duration were completed in six weeks with three sessions per week in which the training session organized at the school field. Experimental group being given CoBAgi Training as in Table 2 while control group trained as usual under the supervision of the researcher. Participants in control group was not given any special intervention which they just practice their normal training.

Table 1. Demographic Data of Experimental Group and Control Group

Variables	Experimental Group	Control Group
Gender	9 males/6 females	8 males/7 females
Age (Years)	14.13 ± 0.83	13.6 ± 0.91
Height (cm)	162.13 ± 7.48	158.0 ± 7.06
Weight (kg)	51.45 ± 7.15	51.33 ± 5.73
BMI (kg÷cm²)	19.5 ± 1.76	20.53 ± 1.49

NOTE: cm - Centimetre or centimetre is a unit of length in the metric system; kg - Kilogram; BMI - Body Mass Index; cm² - cm² is part of a group of pressure units that relate pressure with weight; ± - Values are presented as mean ± standard error.

Table 2. Coordination, Dynamic balance and Agility Intervention (CoBAgi Protocol)

Session		Protocol 1	Sex x Rep	Protocol 2	Set x Rep
WEEK 1	1	Single leg cone touch (Left and right)	2 x 8 2 x 8	Knee to chest hopping	4 x 5
		Single leg cross cone touch (Left and right)	2 x 8 2 x 8	Knee to chest side to side hopping	4 x 5
	2	Single leg cone touch (Left and right)	2 x 8 2 x 8	Knee to chest hopping	4 x 5
		Single leg cross cone touch (Left and right)	2 x 8 2 x 8	Knee to chest side to side hopping	4 x 5
	3	Single leg eye close cross cone touch (Left and right)	2 x 8 2 x 8 2 x 8 2 x 8	Knee to chest variation hoping	4 x 6
		20 Meter 4 stop sprint	10 Reps	Forward squad jump	4 x 6
	4	Single leg eye close cross cone touch (Left and right)	2 x 8 2 x 8 2 x 8 2 x 8	Knee to chest variation hoping	4 x 6
		20 Meter 4 stop sprint	10 Reps	Forward squad jump	4 x 6
Week 2	5	20 Meter 4 stop sprint	10 Reps	Forward squad jump	4 x 6
		20 Meter Zig Zag Sprint.	10 Reps	Backward squat jump	4 x 6
	6	20 Meter Zig Zag Sprint.	10 Reps	Backward squat jump	4 x 6
		Plyo-lunges side to side jump.	3 x 8	Backward run turn and speed	12
Week 3	7	20 Meter Zig Zag Sprint.	10 Reps	Backward squat jump	4 x 6
		Plyo-lunges side to side jump.	3 x 8	Backward run turn and speed	12
	8	Plyo-lunges side to side jump.	3 x 8	Backward run turn and speed	12
		Single leg side to side hopping (left and right)	2 x 8 2 x 8	Alternate single leg knee to chest forward jump	4 x 6
	9	Reactive 20 Meter 4 stop sprint	13 Reps	Reactive 20 Meter Zig Zag stop Sprint.	13 Reps
		Single leg side to side hopping (left and right)	2 x 8 2 x 8	Alternate single leg knee to chest forward jump	4 x 6
Week 4	10	Reactive 20 Meter 4 stop sprint	13 Reps	Reactive 20 Meter Zig Zag stop Sprint.	13 Reps
		Single leg side to side hopping (left and right)	3 x 8 3 x 8	Alternate single leg knee to chest forward jump	4 x 8
	11	Reactive 20 Meter 4 stop sprint	13 Reps	Reactive 20 Meter Zig Zag stop Sprint.	13 Reps
		Resistance knee to chest variation hopping	4 x 15 seconds	Resistance hip switch & blocking	20 Reps
	12	Resistance knee to chest variation hopping	4 x 15 seconds	Resistance hip switch & blocking	20 Reps
		Single leg ball swing & passing	3 x 8	Jump to receive	4 x 8
Week 5	13	Resistance knee to chest variation hopping	4 x 15 seconds	Resistance hip switch & blocking	20 Reps
		Single leg ball swing & passing	3 x 8	Jump to receive	4 x 8
	14	Resistance single leg ball swing & passing	3 x 8	Resistance jump to receive	4 x 8
		Reactive hoping and 20 meter sprint while receiving ball.	13 Reps	Resistance side step & shooting.	13 Reps
	15	Resistance single leg ball swing & passing	3 x 8	Resistance jump to receive	4 x 8
		Reactive hoping and 20 meter sprint while receiving ball	13 Reps	Resistance side step & shooting.	13 Reps
Week 6	16	Hip switch, feint and shooting.	15 Reps	Squat Jump, cut & jump shoot with resistance	15 Reps
		Squat Jump cut & jump shoot with resistance	15 Reps	20 meters zig zag sprint challenge feint to receive and shoot.	15 Reps
	17	Hip switch, feint and shooting.	15 Reps	Squat Jump, cut & jump shoot with resistance	15 Reps
		Squat Jump cut & jump shoot with resistance	15 Reps	20 meters zig zag sprint challenge feint to receive and shoot.	15 Reps
	18	Hip switch, feint and shooting.	15 Reps	Squat Jump, cut & jump shoot with resistance	15 Reps
		Squat Jump cut & jump shoot with resistance	15 Reps	20 meters zig zag sprint challenge feint to receive and shoot.	15 Reps

NOTE: Plyo - plyo refer to exercises in which muscles exert maximum force in short intervals of time with the goal of increasing power.

Statistical Analysis

The recorded data were statistically processed using the IBM Statistical Package for Social Sciences version 22.0. Data were used to display as in mean, standard deviation, t-value and p-value after the analysis, the mean difference for measuring variables were statistically tested using independent sample t-test to compare the result on scores differences between pretest and posttest within group and between group. Graphs were plotted to show the changes in all related variables. All statistical tests were tested at P< 0.05.

Results

The effect of CoBAgi training in SEBT score

As demonstrated in Figure 1, there was a statistically significant difference within group in EG for SEBT score (t = - 4.556, P= 0.000*) where EG showed significant improvement in functional reaching score for the posttest. After six weeks with CoBAgi training, there was (6.51 cm) improvement for functional reaching for posttest in EG from 68.07 ± 2.98 cm to 74.58 ± 2.73 cm (Table 3). However, CG indicated that there was no significant difference within group in SEBT score (t = - 0.448, P= 0.661) i.e. the mean score SEBT in functional reaching was from 67.18 ± 2.44 cm for pretest and 67.78 ± 2.93 cm for posttest (Table 3).

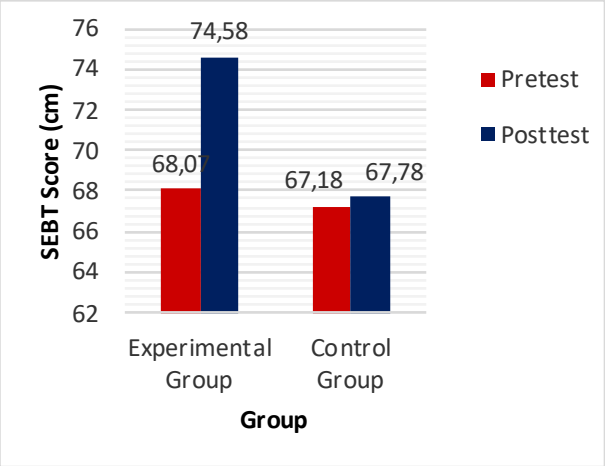

Figure 1. The Comparison Scores of Pretest and Posttest for SEBT between and within experimental group and control group after Six Weeks of CoBAgi Training

The pretest value for SEBT between score EG and CG before six weeks of CoBAgi Training t= 0.653, *P*= 0.525 indicated subjects were from homogenous group. After six weeks of intervention, there was significant difference between EG and CG in the posttest (t = 4.802, *P*= 0.000*) where mean score for EG in the posttest was 74.58 ± 2.73 cm and mean score for CG was 67.78 ± 2.93 cm i.e. the score difference was 6.80 cm (Table 3).

The effect of CoBAgi training in Carioca score

As demonstrated in Figure 2, there was a statistically significant difference within pretest and posttest of EG for Carioca score (t = 2.596, *P*= 0.015*) where EG showed significant improvement in posttest indicating after six weeks with CoBAgi training, there was reduction in time taken to complete carioca test for posttest in EG i.e. 10.60 ± 2.02 sec. to 8.70 ± 2.00 sec. (reduction of 1.90 sec.) (Table 4). However, CG indicated that there was no significant difference within pretest and posttest in Carioca score (t = - 0.875, *P*= 0.389) i.e. the mean score for time taken to complete Carioca test was pretest 10.57 ± 1.51 sec. and posttest 10.11 ± 1.33 sec. (Table 4).

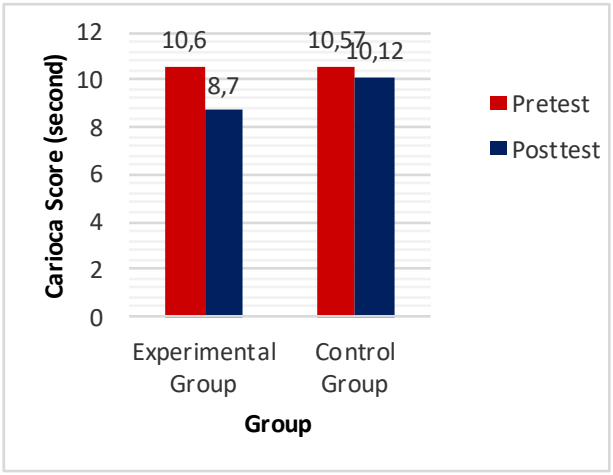

Figure 2. The Comparison Scores of Pretest and Posttest for Carioca test between and within experimental group and control group after Six Weeks of CoBAgi Training

The pretest value for Carioca test between EG and CG before six weeks of CoBAgi Training was t= 0.046, p= 0.964 indicating EG and CG were from homogenous group. After six weeks of intervention, there was significant difference between EG and CG in the posttest

Table 3. The Comparison of Pretest and Posttest Between and Within Control Group and Experimental Group in SEBT Score after Six Weeks with CoBAgi Training

Group	Pre μ ± SD	Post μ ± SD	t	*P*
Experimental Group	68.07 ± 2.98	74.58 ± 2.73	-4.556	0.000*
Control Group	67.18 ± 2.44	67.78 ± 2.93	-0.448	0.661
Group				
t	0.653	4.802		
P	0.525	0.000*		

NOTE: SD - Standard Deviation; ± - Values are presented as mean ± standard error.

(t= -2.290, P= 0.030*) where mean score for EG in the posttest was 8.70 ± 2.00 sec. and mean score for CG was 10.11 ± 1.33 sec. (i.e. the score difference for EG and CG was 1.41 sec.) (Table 4).

The effect of CoBAgi training in L-Run score

As demonstrated in Figure 3, there was a statistically significant difference within pretest and posttest of EG for L-Run score (t = 2.680, P= 0.012*) where EG showed significant improvement in posttest indicating after six weeks with CoBAgi training, there was reduction in time taken to complete L-Run test for posttest in EG i.e. 6.92 ± 0.75 sec. to 6.23 ± 0.69 sec. (reduction of 0.69 sec.) (Table 5). However, CG indicated that there was no significant difference within pretest and posttest in L-Run score (t = -0.045, P= 0.964) i.e. the mean score for time taken to complete L-Run test was pretest 7.04 ± 0.74 sec. and posttest 7.05 ± 0.74 sec. (Table 5).

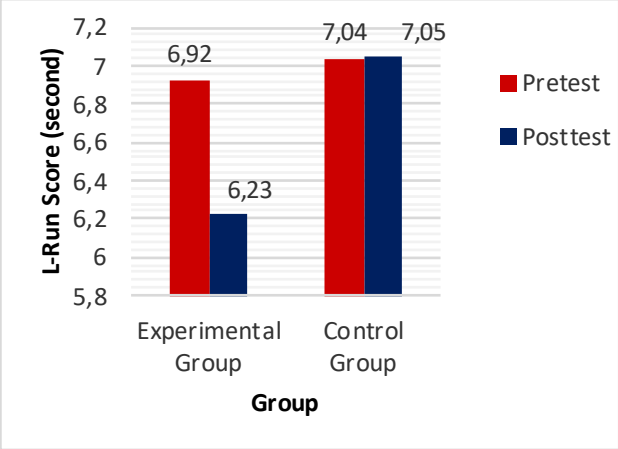

Figure 3. The Comparison Scores of Pretest and Posttest for L-Run test between and within experimental group and control group after Six Weeks of CoBAgi Training

The pretest value for L-Run test between EG and CG before six weeks of CoBAgi Training was t= 0.653, P= 4.802 indicating EG and CG were from homogenous group. After six weeks of intervention, there was significant difference between EG and CG in the posttest (t = -3.202, P= 0.003*) where mean score for EG in the posttest was 6.23 ± 0.69 sec. and mean score for CG was 7.05 ± 0.74 sec. (i.e. the score difference for EG and CG was 0.82 sec.) (Table 5).

Discussion

This six weeks' study on CoBAgi training among adolescent handball players revealed the beneficial effects on coordination, dynamic balance and agility. The key findings of this study were that subjects were able to improve time taken to complete carioca and L-Run test which determine coordination and agility and also able to increase the distance reach in SEBT test which determine dynamic balance in post training testing throughout the six weeks CoBAgi Training.

There was significant improvement in time taken to complete carioca test between pre and post testing which signifies the improvement of coordination. This indicates CoBAgi training could have a beneficial effect on coordination in adolescent handball players. Coordination is a well-ordered complex motor activity of various organs and systems that necessary for high performance activity. Ricotti clarified it is relying on movement control and necessary in sports, which allow players to control their own motor actions easily and allow the learning of complex movements in a relatively rapid way [8]. Coordination improvement in adolescent is crucial and based on Yasumitsu, this will initiate rhythm skills, balance skills, transformation skills, reaction skills, consolidation skills, orientation skills and

Table 4. The Comparison of Pretest and Posttest Between and Within Control Group and Experimental Group in Carioca Score after Six Weeks with CoBAgi Training

Group	Pre μ ± SD	Post μ ± SD	t	*P*
Experimental Group	10.60 ± 2.02	8.70 ± 2.00	2.596	0.015*
Control Group	10.57 ± 1.51	10.11 ± 1.33	0.875	0.389
Group				
t	0.046	-2.290		
P	0.964	0.030*		

NOTE: SD - Standard Deviation; ±, Values are presented as mean ± standard error.

Table 5. The Comparison of Pretest and Posttest Between and Within Control Group and Experimental Group in L-Run Score after Six Weeks with CoBAgi Training

Group	Pre μ ± SD	Post μ ± SD	t	*P*
Experimental Group	6.92 ± 0.75	6.23 ± 0.69	2.680	0.012*
Control Group	7.04 ± 0.74	7.05 ± 0.74	-0.045	0.964
Group				
t	-0.434	-3.202		
P	0.667	0.003*		

NOTE: SD - Standard Deviation; ±, Values are presented as mean ± standard error.

recognition skills to be translated into excellent specific skill performance [15]. Adolescent handball players would be believed to experience improvement in terms of interaction between muscles that control the movement and resulted in improved reaction skills, thus, enhanced intermuscular coordination [11, 15]. In detail, the most contributing factors perhaps due to improvement in space-time orientation ability, kinesthetics differentiation, rhythm ability, agility and balance [15, 16] which being interpreted as short time taken to complete the task. It is because when player able to recognize the space within the time, prediction of action will be created cognitively and when triggered with signal, body will move rhythmically as well as balance would controlling the agility reflect [17, 18] and this how coordination take place. Considering all the facts, CoBAgi training has significantly improve coordination among adolescent handball players.

There was also significant improvement of distance reached in SEBT test between pre and post testing and this shows improvement in dynamic balance. Improvement in muscular synergies help minimize the displacement for centre of gravity in which, contribute for proper control of body balance to execute motor task [8]. This could be the reason why adolescent handball players able to maintain the stability while reaching the longer distance with only single stand. Also, the impact of improvement could reduce static postural sway and could decrease ankle or knee injuries in team handball [11, 14]. Efficiency of this would provide positive advantage among the players. Furthermore, Integration of visual, auditory and proprioceptive (somatosensory) i.e. components of dynamic balance is capable to control body movement in space especially in sports setting [19]. Stability will reduce or even lost if stability being disturbed. Since, mechanism of dynamic balance starts when visual received the signal, it will digest the input based on stored information and interpret the demand cognitively. Initiation of movement is the result of reflection from visual input while auditory balance the body. In the meantime, proprioceptive is actually protecting the joint and muscle from excessive move which perhaps may lead to injury. According to a study, information from proprioceptors is key for conscious and unconscious control of limb movement, both for the initiation and during movements [20]. In addition, proprioceptive signals are essential for the intact neural control of movement whereas damage of proprioceptive afferents could affect the control of muscle tone, disrupts postural reflexes and severely damages spatial as well as temporal aspects of volitional movement [21]. For that, this improvement could have justified that the integration of all the components as well as performance in proprioceptive been enhanced whereas damage of it would damage the performance. Thus, apart from coordination, six weeks CoBAgi training has considerably improve dynamic balance of the adolescent players.

Apart from coordination and dynamic balance, agility also shows improvement since time taken to complete L-Run test is shorter between pre and post testing. Favourable adaptations on endurance, muscle power, balance and strength [22] may experience by adolescent handball players. This improve their ability to be responsive such change position, direction of movement and reaction to a stimulus with speed and efficiently. Besides, move in accurate direction, and ready to change direction or stop quickly to make the play fast, smooth, efficient, and in repeatable manner [15]. Technically, this improvement was due to the re-enforcement of motor programming by neuromuscular conditioning and neural adaptation of muscle spindles, golgi-tendon organs, and joint proprioceptors [21]. These would be successful through specific learning process which imposed specificity such CoBAgi training. Responsiveness is the main part in agility and its associated with stop-and-go patterns, accelerations, decelerations, eccentric loads, changes of direction (cutting manoeuvres), and combined with demanding spatial orientation tasks [22]. Based on these facts, we may assume a successful agility requires integration of ability to react on stimulus, ability to change velocity, ability to change direction and perceptual decision making. The mechanism starts with perceptual decision making where analysis occurred cognitively, and thus it is advantage for those who has lots of information to predict on possibilities that might happen and also the corrective mechanism that could be taken. On this situation, signal already sent to the respective systems and proprioceptors activated to take charge during motor task. So that, it speeds up the information processing, thus the reflects as mentioned before could be execute quickly and safely. After all, it shows integration of neuromuscular system through neural adaptation understand such resistance as habit and thus individual able to execute motor task effectively. As suggested, intervention training with agility would enhanced neuromuscular performance as well as cognitive functioning [22].

Outcomes of present study were actually the result from combination of neuromuscular training, sport specific movement couple with perturbation which expressed as CoBAgi training. Adolescent handball players improve after six weeks of intervention. Sawdon-Bea and Nicole stated, incorporating sport specific tasks help players/athletes to be at optimal performance [19]. To be clear, neuromuscular and sport specific training are common approach among practitioners, however, the use of perturbation is less selective and mostly implemented on stroke and post-operative knee patients. From this study, we could identify how actually perturbation would be beneficial among healthy community especially sport players. Perturbation through controlled, unpredictable, and multidirectional forces during the motor task encourage proprioceptive ability to accelerate [23]. In detailed, the challenges given on motor function e.g. quick stops, turns, changes in direction, challenges to balance and negotiating obstacles just in sudden [24]. Perhaps the best technique is without giving any visual clues. Eventually, this would alter proprioceptive (somatosensory) and make it flexible with upcoming resistance [23].

Conclusion

In short, the physiological adaptation was due to alteration of neural system adapted with simulated game movement i.e. sensitivity of muscle spindles increases within the muscles, so it may result in a higher readiness in responding to any destabilize forces, and this would contribute for performance and prevent excessive movement within the joint [10, 25]. Taken together, CoBAgi training could be an alternative program to improve performance, pre-rehabilitation as well as rehabilitation for post injuries. However, the actual success factors may have limited and not be clearly defined. Thus, for further studies, the assessment should include muscle recruitment for specific components, and such effort will lead for specific program and outcome.

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Conflict of interest

The authors declare that no conflict of interest.

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ORIGINAL ARTICLE

Differences in the degree of nutrition and body composition of boys and girls of pubertal age

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: The nutritional status of children can be assessed on the basis of clinical examination, laboratory procedures and anthropometric measurements. Height and body weight are most often used to determine nutrition. Children and adolescents who are at risk of being overweight often also become obese adults.

Material: The research was conducted on a sample of 136 students (67 boys and 69 girls), with an average age of 11.56 years. The aim of the study was to determine the degree and differences in the degree of nutrition and body composition in boys and girls of pubertal age.

Results: Based on the obtained results, T-test for small independent samples, it was determined that there are no statistically significant differences between boys and girls, both in the degree of nutrition and body composition, estimated by 10 variables using bioelectric impedance InBody 720. Also, it was found that 19.70% of boys are obese, as well as 17.40% of girls. Cumulatively with the percentage of malnourished respondents, a total of 61.50% of boys were not normally fed, as were 37.70% of girls. The obtained results indicate the need for a more extensive review of the analysed segments and a significantly larger sample of respondents, in order to act preventively in the fight against obesity, as the leading epidemiological health problem of today.

Conclusions: It is obvious that physical activity based on physical education classes is not sufficient or is not sufficiently represented to meet the challenges of the modern way of life of children.

Keywords: obesity, health, growth, development, Body Mass Index, Body Height, Body Weight.

Introduction

Monitoring the nutritional status is a very useful activity because it indicates the adequacy of the process of growth and development of children, helps to understand the current, and can also serve as a prognostic factor for their future health. The nutritional status of children can be assessed on the basis of clinical examination, laboratory procedures and anthropometric measurements. Height and body weight are most often used to determine nutrition. Children and adolescents who are at risk of being overweight often also become obese adults. Numerous characteristics of parents, including their education and income, influence the formation of the child's eating and living habits, and a particularly large role is attributed to the mother [1]. Small bodies need a quality diet to "survive" the school day, and the child's brain is hungrier than the body, it needs oxygen, energy, key nutrients, especially iron (Fe), magnesium (Mg) and B vitamin complex. If these needs are not met, children will have difficulty learning, remembering and maintaining concentration [2]. Proper nutrition of children should satisfy the body's need for daily energy intake and a sufficient amount of nutrients and protective substances that are necessary to maintain the physiological functions of the body and health. In addition to inadequate nutrition, physical activity also plays a significant role in the level of body fat in the body. There is less and less space to play outside. Today, children play in houses, indoors, and these are the most common games on the computer, mobile phone and play station. Lack of play leads to a decrease in the use of natural forms of movement, which affects the reduced level of motor skills, and thus to lower calorie consumption [3]. The most significant disorder is obesity, which is increasingly prevalent in adolescent children. Ten years ago, statistical data showed that 10.5% of children in Croatia have increased body weight, and 3.8% of them are obese. The latest data from the Croatian Institute of Public Health (HZJZ) indicate that 26.4% of school-age children are overweight, while 11.2% are obese. Croatia is in a worrying FIFTH place in Europe in terms of the number of overweight children [4]. According to the World Health Organization [5], childhood obesity is one of the biggest global public health challenges of the 21st century, and it is estimated that in the last 40 years, the number of obese school-age children and adolescents has increased tenfold. The etiology of childhood obesity is very complex, but dietary and life habits play a very important role [6]. Baranowski, Taveras [7] point out that the current approach to childhood obesity has not yielded the expected results and that preventive measures need to be strengthened activities at all levels, starting with

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parents. In the study conducted on the ITOF criterion, the majority of children, 165 and 65.74%, respectively, were normally fed, as many as 21.51% were malnourished, while children with increased body weight were 7.97% and 4.78% obese, without significant statistical difference according to the sex of children [8]. Therefore, the diagnosis of the state of body composition is often the subject of research based on which a realistic insight into the current state of the defined population and possible negative or positive trends of growth and development over a period of time [9]. Based on all the above, the aim of this study is to determine the degree and differences in the degree of nutrition and body composition in boys and girls of pubertal age.

Material and methods

Participants

The study included a sample of 136 students divided into two subsamples: 67 boys with average values of Body Height (BH) 156.44 ± 10.37 cm, Body Weight (BW) 50.25 ± 11.57 and Body Mass Index (BMI) 20.32 ± 3.22 kg / m^2, chronological age 11.63 ± 0.95 years and 69 girls average BH 156.31 ± 8.09 cm, BW 49.07 ± 12.09 kg and BMI 20.1 ± 3.66 kg / m^2, chronological age 11.55 ± 0.90 years.

The sample of variables

The sample of variables used in the study represents a set of 13 variables. To assess the anthropometric characteristics, 3 variables were taken: body height (BH), body weight (BW) and body mass index (BMI). To assess body composition, 10 variables were identified:

- Total Body Water, L (TBW);
- Proteins, kg; Minerals, kg;
- Body Fat Mass, kg (BFM);
- Soft Lean Mass, % (SLM);
- Ratio, %; BFM / SLM;
- Fat Free Mass, kg (FFM);
- Skeletal Muscle Mass, kg (SMM);
- Minerals in the Bones, % (MB);
- Percent Body Fat, % (PBF).

Research Design

Anthropometric variables were measured according to standard procedures of the International Society for the Advancement of Kinanthropometry (ISAK) [10]. Based on the variables BH and BW, BMI [BMI = BH (kg) / BW $(cm)^2$] was calculated. BMI values for both subsamples were classified into 4 nutritional levels, according to the recommendations of the Centers for Disease Control and Prevention, 2000 [11] Table 1.

Table 1. Categorization of nutrition based on percentiles

BMI	Percentile	Weight
BMI ≥	95th percentile	Obesity
BMI =	85-95th percentile	Overweight
BMI =	5-85th percentile	Normal weight
BMI ≤	5th percentile	Malnutrition

Body composition was measured with an InBody720 scale [12]. The validity of determining the body composition with InBody720 scales on a sample of children has been positively evaluated in some previous studies [13,14]. The research was approved by the Ethics Commission of the Faculty of Education, University of Sarajevo [15]. All parents are informed in advance about the implementation of the research which explains the purpose and goal of the research. Therefore, the research was supported by all parents, with written consent.

Statistical Analysis

All data collected by the research were processed by descriptive and comparative statistics. From the space of descriptive statistics, the arithmetic means, and standard deviation were calculated for each variable, while the T-test for small independent samples was used to determine the differences. The statistical program for personal computers SPSS for Windows-version 20.0 was used for data processing.

Results

Table 2 presents the results of the T-test for small independent samples and the results of the basic parameters of descriptive statistics, arithmetic mean (Mean) and standard deviation (Std.Dev). Based on the obtained values, it was determined that there are no statistically significant differences between the respondents, i.e. that the variances are the same in all variables by groups. Insight into the results of the arithmetic mean for all variables, it can be confirmed that these are approximately the same values, with slight differences, which are not recognized by statistical processing and application of the t-test.

Table 2. Differences in the BMI between boys and girls – Descriptive statistic, T-test

Variables	Gender	Mean±Std. Dev.	T-test	
			t-value	P
Body Height (cm)	♂	156.44±11.57	.083	.934
	♀	156.31±8.09		
Body Weight (kg)	♂	50.25±11.57	.579	.564
	♀	49.07±12.09		
Body Mass Index (kg/m^2)	♂	20.32±3.22	.757	.450
	♀	20.1±3.66		

Legend: Male-♂; Female-♀.

Table 3 shows the percentile values for the variable BMI, based on which it is possible to see the nutritional status of the subjects by gender and level of nutrition. A very high percentage of overweight and obese respondents is evident, especially among boys (41.80% overweight and 19.70% obesity). The degree of obesity is approximately equal between boys and girls (19.7% -17.4%), while there is a significant difference between the degree of normal nutrition (38.80% - 60.90%).

In Figure 1 and 2, the arithmetic means of the percentile values for BMI were positioned, in both sexes. In the boy sample, the average percentile value is 85th percentile, which indicates that it is a subsample that is on the border between normal nutrition and malnutrition. A slightly milder picture of the nutritional status is found in girls, but with a very similar tendency towards the boundary between the degree of normal and excessive nutrition of the complete subsample.

Analysing the results, shown in Table 4, it is noticeable that there are some gender differences in the indicators of body composition between boys and girls of pubertal age. However, as these differences can only reflect random variations in the sample, their significance was examined using a t-test for small independent samples. Analysis of T-test results shows that there are no statistically significant differences in body composition between boys and girls, in any of the 10 variables.

Discussion

The results of this study found that there were no statistically significant differences between boys and girls, both in the level of total nutrition assessed by body mass index (BMI) and in the body composition determined by the bioelectrical impedance InBody720. Based on the frequency of percentile values, 19.70% of boys and 17.40% of girls were found to be obese. The results obtained in this study have significantly higher values compared to the results obtained on a sample of respondents aged 11 ± 6 years obtained by [16]. In this study, boys had average values: BH: 146.60 cm, BW: 40.78 kg and BMI: 18.83 kg / m2, while in girls the values were: 147.40 cm, 40.50 kg and 18.57 kg / m2. The prevalence of obesity in the pediatric population has increased threefold in the most developed countries over the past 20 years, and it is thought that such a condition will have a number of negative health consequences in the future [17]. The results showed that a large percentage of boys were overfed (41.80%), which together with boys who are obese (19.70%) amounts to an alarming 61.50% of respondents who do not have a normal level of nutrition. In girls, the condition is somewhat different, and the results show that about 37.70% do not have normal nutrition. However, based on Figure 2, it can be concluded that girls are mostly fed to a degree that is on the verge of normal nutrition, i.e. close to malnutrition, so the statistical procedure and the application of the T-test did not reveal differences at a statistically significant level between the sexes. Increased nutrition on the side of boys compared to girls has been found in previous researches. Jakšić et al. [18] stating the results: „Directorate for employment, labour and social affairs, data from 2014, the highest prevalence of OWOb (overweight/obesity) was recorded in Greece (44% of boys and 38% of girls) followed by Italy (36% vs. 34%), New Zealand (34% vs. 34%), USA (30% vs. 30%), while the lowest prevalence was recorded in Indonesia (11% vs.8%). Differences between prevalence of OWOb in favor of boys were found in China (24%vs. 16%), Hungary (28%vs.23%), Poland (17% vs. 11%), whereas differences in favor of girls are present in South Africa (29% vs. 11%) and UK (26% vs. 22%).'' The results of the research showed that apart from the fact that there is no difference in the level of nutrition of the respondents, there is also no difference in their body composition. Accordingly, it can be stated that these are respondents who have approximately the same lifestyle when it comes to nutrition, as well as physical activity. High values of free fats expressed in kilograms in girls and boys (37.99 vs 36.13), as well as the results of PBF (23.74 vs 24.68), and according to the percentile values of the level of nutrition of the subjects (85th vs 78th), it can be concluded that this is a sample of subjects whose lifestyle has no balance between diet, i.e. calorie intake and their consumption by physical activity. Obesity as a health problem in childhood has multiple causes, so in its solution it is necessary to apply a broad therapeutic approach that requires the participation of patients, family and environment. Therefore, nutrition depends on the relationship between energy production and its consumption in the human body [19]. Puberty is a succession of anatomical and physiological changes in early adolescence that mark the transition period from sexually immature to fully mature and is characterized by the development of reproductive functions, changes in body size, composition and function in response to sex hormones [20]. If in this period intensive growth

Table 3. Nutritional status and percentiles boys and girls

Nutritional status	Boys			Girls		
	n	Percentiles	%	n	Percentiles	%
Obesity	13	≥95	19.70	12	≥95	17.40
Overweight	28	85-95	41.80	14	85-95	20.30
Normal weight	26	5-85	38.80	42	5-85	60.90
Malnutrition	0	<5	0.00	1	<5	1.40
Total:	67		100.0	69		100.0

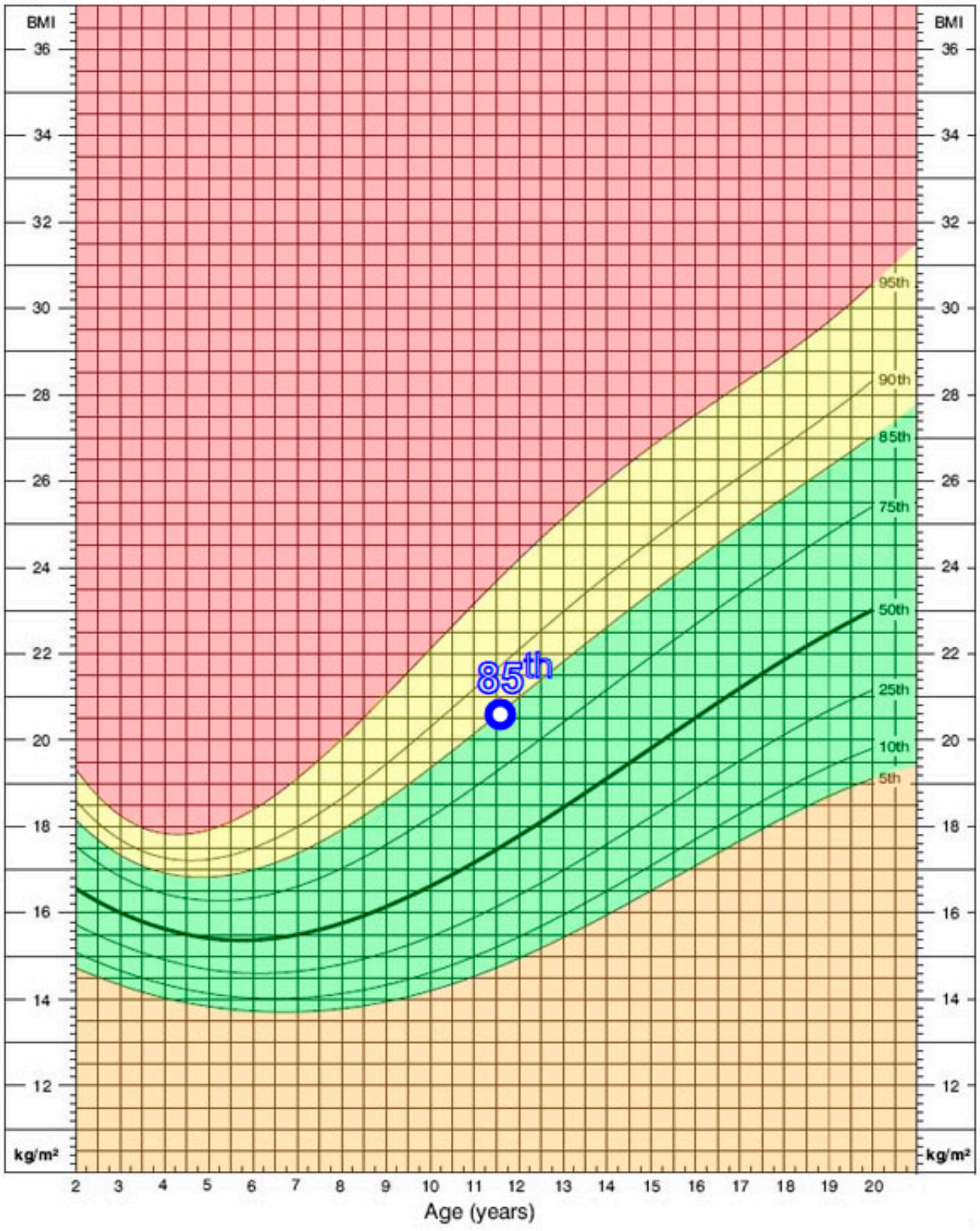

Figure 1. Percentile values of boys

and development are not based on healthy habits, the risk of developing various diseases, both in youth and in adulthood, is inevitable. In our country, as in the region, every third child spends three to five hours a day in front of a computer or TV, which significantly affects weight gain [21]. Kosti, Panagiotakos [22] point to the need to take urgent measures to combat obesity that has reached epidemiological proportions, where otherwise 1.3 million new cases of obese children can be expected worldwide. Đurković [23] points out that obesity, in addition to affecting a person's health status, also affects work productivity, as well as financial expenditures for the treatment of overweight and obese people. It is necessary to keep in mind that obesity, in both boys and girls, causes

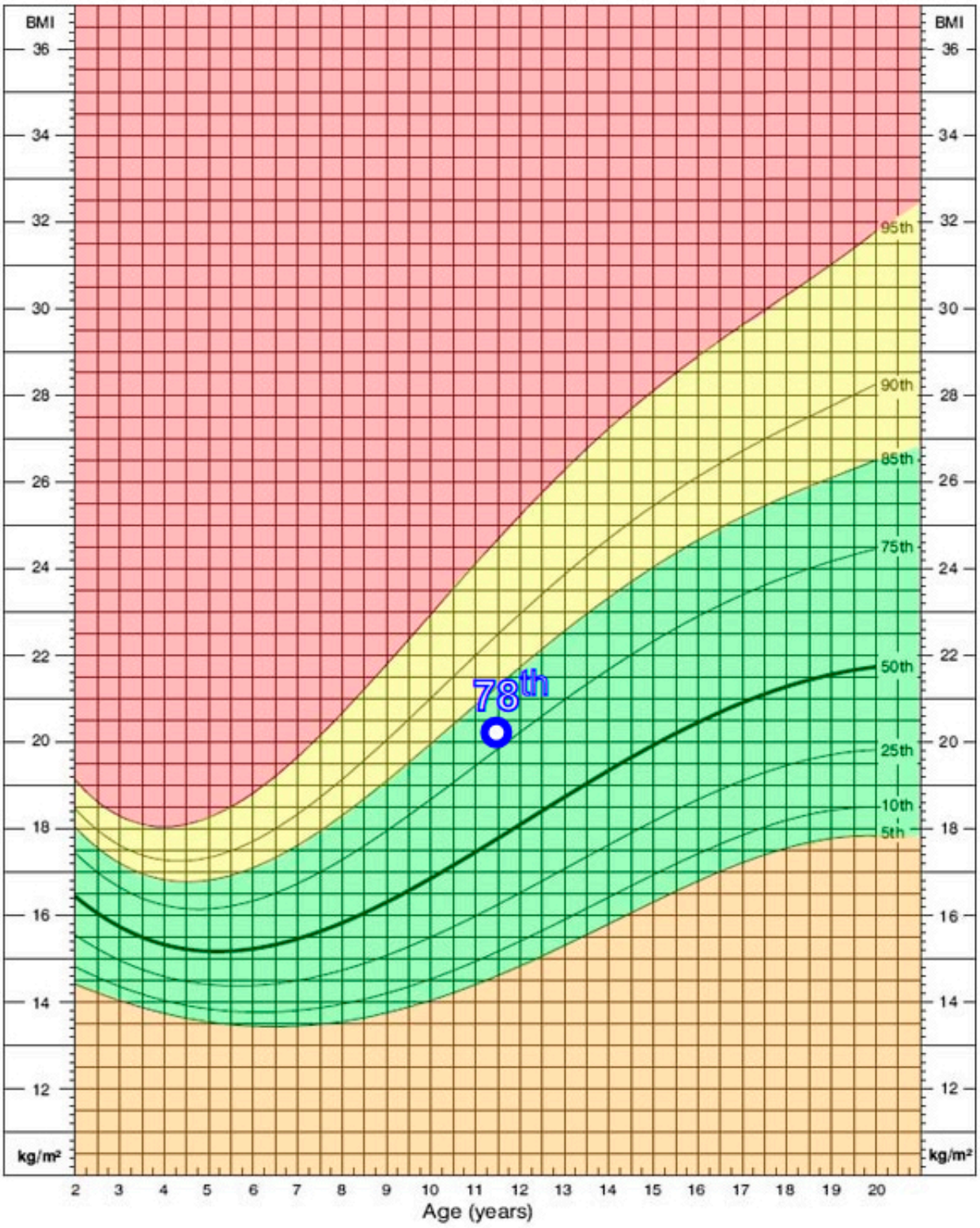

Figure 2. Percentile values of girls

dissatisfaction with their own appearance, which can cause various psychological processes in children, such as depression, withdrawal, non-fulfilment of their own potentials and others.

Conclusion

Obesity, as a health problem of the modern way of life, has gained epidemiological proportions around the world. It is obvious that this wave of epidemics is widely present in our country and in our immediate vicinity. Based on data indicating that 61.5% of male respondents and 37.70% of female respondents do not have normal nutrition, it can be concluded that our respondents are largely in the range of obesity and overeating with respondents from most developed countries, where obesity is the leading epidemiological health problem.

Table 4. Differences in the body composition between boys and girls – Descriptive statistic, T-test

Variables	Gender	Mean±Std.Dev.	T-test	
			t-value	P
TBW	♂	27.86 ± 6.47	1.289	0.20
	♀	26.60 ± 4.8		
Proteins	♂	7.47 ± 1.75	1.432	0.15
	♀	7.09 ± 1.30		
Minerals	♂	2.67 ± 0.61	0.979	0.32
	♀	2.57 ± 0.49		
BFM	♂	12.25 ± 6.72	-0.467	0.64
	♀	12.79 ± 6.78		
SLM	♂	35.79 ± 8.31	1.314	0.19
	♀	34.14 ± 6.19		
Ratio BFM/SLM	♂	0.35 ± 0.19	-0.364	0.71
	♀	0.36 ± 0.15		
FFM	♂	37.99 ± 8.82	1.391	0.16
	♀	36.13 ± 6.65		
SMM	♂	20.50 ± 5.28	1.364	0.17
	♀	19.40 ± 3.94		
MB	♂	2.20 ± 0.51	0.679	0.49
	♀	2.15 ± 0.42		
PBF	♂	23.74 ± 9.85	-0.604	0.54
	♀	**24.68** ± **8.11**		

NOTE: Total Body Water, L; BFM - Body Fat Mass, kg; SLM - Soft Lean Mass, %; FFM - Fat Free Mass, kg; SMM - Skeletal Muscle Mass, kg; MB - Minerals in the Bones, %; PBF - Percent Body Fat, %.

The obtained data, although conducted on a small sample, indicate the need for urgent consideration of things when it comes to this health problem and the inclusion of all segments of society in solving the problem. It is obvious that physical exercise, represented through the teaching of physical education in primary school, cannot respond and act preventively on the challenges of the modern way of life of children.

Conflict of interest
Authors declare no conflict of interest

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ORIGINAL ARTICLE

The effect of functional and supportive classic strength trainings in basketball players on aerobic strength, dynamic balance and body composition

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: It has been aimed to investigate the effects of functional and supportive classic strength trainings in basketball players on aerobic strength, dynamic balance and body composition.

Material: In the study, the test group has performed functional + supportive classic strength training (n=15; 20, 8 ± 1,7 year) three days in a week for eight weeks. Within the process, test and control groups have also continued basketball technical tactics trainings two days in a week. The control group (n=15; 21, 06 ± 1,9 year) has not performed any strength training. The participants have been tested in terms of height, body weight, skinfold calipers, watt bike pro ramp aerobic capacity test and libra see saw balancing board test. When identifying the percentage of body fat, lunge formula has been used. The data has been evaluated with Repetitive Measurements Anova Test.

Results: In comparing the group x time interaction, while the developmental difference in the values of VO_{2max} Estimate (mg/kg/min), MET, the percentage of body fat and Left foot lateral balance test has been found out statistically substantial in test and control groups, no significant difference in lateral balance on both feet, right foot lateral balance the measurements and transfer balance measurements on both feet has been found out.

Conclusions: As a consequence, it has been seen that functional and supportive strength trainings have contributed to the percentage of body fat, aerobic capacity and dynamic balance. In the planning of yearly training it has been seen that functional strength trainings in preparation phase will contribute to the development levels of basketball players.

Keywords: functional strength trainings, dynamic balance, body composition, aerobic capacity.

Introduction

The functional training has been attracting the attention as an approach which has enriched its popularity day by day throughout world and placed in training modalities by several teams and sportsmen. When examining the content of functional training generally, it has been seen that it includes close movements to the movements of specific sports branch performed by sportsmen [1]. ACSM (American College of Sports Medicine) Functional Training; just as neuromotor trainings; has been described as a training method including balance, coordination, mobility, agility and proprioceptive skills [2]. The thing that mainly operationalizes functional training is to provide the transfer of existing performance parameters to sportive performance in a successive way [3]. Therefore, it aims to train sportsmen with the help of the patterns based on the movements in real life (e. g. flexibility, mobility, throwing, bending and spinning etc.) [4, 5] It has been seen that functional training is more effective than classic resistance and strength trainings and that is because it has been performed in multi junction and different platforms [6]. It is important to create kinetic chains well in transferring existing motor skills. Particularly traditional resistance trainings, these approaches are less stabile compared to functional trainings, provide muscle motor control and this situation makes functional training important in transferring of performance to the competition [7].

Functional training has been generally confused with classic resistance and strength trainings. In limited studies that have been made before, it has been identified that in the sportsmen who are performing especially high intensity functional training both they have achieved approximate values to strength sportsmen and resistance sportsmen are able to generate power against tiredness [8]. Gencer et al have stated that there is no effect of core training model in age group between 9 and 12 on free style swimming performance [9]. It has been known that it also provides increase in efficiency in exercises with combined and multi junction [10]. In the exercises performed in conditions that are not stabile instead of isolated exercises, it has been seen that there are more achievements in the movements which are taken off, balancing and multi-junction movements [11]. None the less, the efficiency of classic exercises should be considered in the parameters of peak strength and time on the ground and dominant strength [12, 13].

As well as the balance complex is a motor skill, it is also a determinant criterion in athletic performance and where auditory, sensory and depth perceptions need

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to work coordinatively [14]. It has been known that functional training is able to improve directly static and dynamic balance regardless of a certain age range [15]. It is known that functional training as dynamic movement chain is increasing the quality of individual's movement because it empowers rebalancing, junctions and tendons and it also develops proprioceptive system [11, 14]. It has been observed that because functional exercises and warm-ups are far from isolation and in an active-dynamic state, they have developed neuromuscular postural control and postural activation protecting sportsmen from injuries [16, 17, 18]. To train sportsmen by using functional movements increases the junction mobility and this provides sportsmen to create more qualified movement chains and decrease injury risks. The balance and stability disorders occurred especially in developmental periods of young sportsmen can be reduced with functional movement exercises [19]. Again, it is known that functional exercises can prevent injuries and gain favor against posture disorders in sportsmen [20].

Specifically balance motor skill takes an important place in basketball branch. It has shown that the basketball players who have active balance and balancing skills are able to have the percentage of shots with average relation [21]. It has been stated that dynamic balance is a non-neglectable concept for trainers, sportsmen and researchers interested in basketball [22]. Both dynamic and static balance skills have been used for basketball branch [23]. Dynamic balance can be described as the balancing skill of sportsmen' center of gravity against a surface or stimulus. It has been seen that articulations and tendons have great role in this balancing [24]. The importance of sub extremity anatomy cannot be debuted in terms of sportsmen's dominating each other [25]. It has been seen that most of the low extremity injuries are caused by lack of dynamic balance skill [26]. It has been stated in balance exercises implemented on basketball players that dynamic balancing is important, and they develop different balancing strategies in every competitor level [27]. It has been seen in functional exercises and functional balancing and stability exercises that sportsmen can improve low kinematics and they are able to decrease injury risks [28, 29, 30]. It has been identified that the basketball players whose static balance values are high have contributed to game scales in a positive way [31]. By suggesting that balance and flexibility should be integrated into training programs because there are sudden changes of direction in basketball, it has been thought that it will affect success of sportsmen and their teams in a positive way [31, 32, 33].

Aerobic strength that has been defined as oxygen amount used in unit of time has drawn attention as an important factor for sportive performance [34]. Anaerobic and aerobic power have an important place in basketball branch [35]. Besides improving VO_{2max} and lactate levels, it is necessary to develop aerobic performance for running economy as well [36]. Basketball branch has highly intensive episodic game structure in literature [37]. Even though using explosive qualifications dominantly ensures more anaerobic qualifications, basketball is defined as an aerobic based game in which anaerobic qualifications are dominant [38]. In that, sportsmen need to pull together in short resting time. In aerobic metabolism, basketball has a vital role in producing energy and providing durableness. While 60 percentage of the durations when the ball is played actively in basketball competition is consumed for low intensity activity is consumed, it has been stated that 15 percentage of it is consumed for high intensity activities [39].

When examining anthropometric values of sportsmen, we see that basketball players are generally tall and weighty. However, it has been seen that the fat centages of this mass are between 6 and 15 in elite sportsmen [40, 41]. It has been observed that sub extremity fat rates are lower in sportsmen whose aerobic qualifications are dominant. It can be thought that sub extremity fat rates of basketball players are higher [42]. Serin and Ziyagil (2020) in their study have stated that there is a decrease in fat percentage of sportsmen at the end of 8 weeks traditional squat eccentric strength training [43].

The study has been designated with the aim of investigating the effects of functional training approach on aerobic power, dynamic balance and body composition as an identified periodizing result.

Material and Methods

Participants

In the research, while test group has implemented basketball + functional + supportive classic strength training (n=15; 20, 8 ± 1,7 year, 196, 4 ± 8,6 cm, 99,08 ± 13,3 kg), on the other hand control group has implemented only basketball training (n=15; 21,06 ± 1,9 year, 190,27 ± 5,9 cm, 96,3 ± 11,2 kg). Healthy and volunteer participants who have taken place actively in basketball branch for five years and struggled in intercollegiate leagues have participated in our study.

Research Design

Initially verbal and oral explanations about the research to be implemented and the measurements to be sized have been made to the individuals participated in the study. The individuals who have accepted to participate in the study have been provided to fill "Volunteer Consent Form". Before the test, a standard gradual warm-up for fifteen minutes has been implemented for each. All tests have been made on the same day and checked by the same researchers and recorded. Training protocol suitable for the defined characteristics of the groups has been implemented.

Data Collection Process

Watt bike Pro Ramp Test Protocol:

Aerobic capacity of the participants can be identified in Watt bike ramp test. Initial watt value according to the active level of the participants in their sports life and their body weight has been specified in ramp test (Table 1). 20 watts increase in each 1 minute has been seen during the implementation of the test. According to Table 1, the participants who have 160 watt and over value in test protocol have been subjected to test 12 fractionally.

Air resistance settings have been implemented in a suitable way to Table 2 for the participants during the test. According to cadence value in each fraction, the participant has been provided to pedal. It has been stated that the participants can optionally terminate the test when needed. At the end of the test, VO_{2max} estimate and MET values have been recorded on watt bike pro digital screen (Figure 1).

When comparing direct measurements, estimated VO2 values used in watt bike pro can give a good guess [±6%]. Estimated VO_{2max} formula value in the study conducted by Störer et al. has been used by watt bike pro [44, 45].

Body Composition (Fat Measurement);

In our research body fat percentage has been identified by using skinfold calipers (Holtain, UK). Skinfold calipers values have been recorded by measuring the right side of the participants' body twice from seven standard areas (Biceps, Triceps, Pectoralis, Sub-scapula, Abdominus, Supra-iliac and Quadriceps). Body fat percentage (%) has been calculated by using skinfold calipers values taken from seven areas of the body (Lange formula; [(Biceps + Triceps + Pectoralis + Sub scapula + Suprailic + Quadriceps) x (0.097) + 3.64] [46].

Dynamic Balance Test Protocol:

Libra see saw balancing board test stand produced by Easy Tech (balancing board; computer set placed on

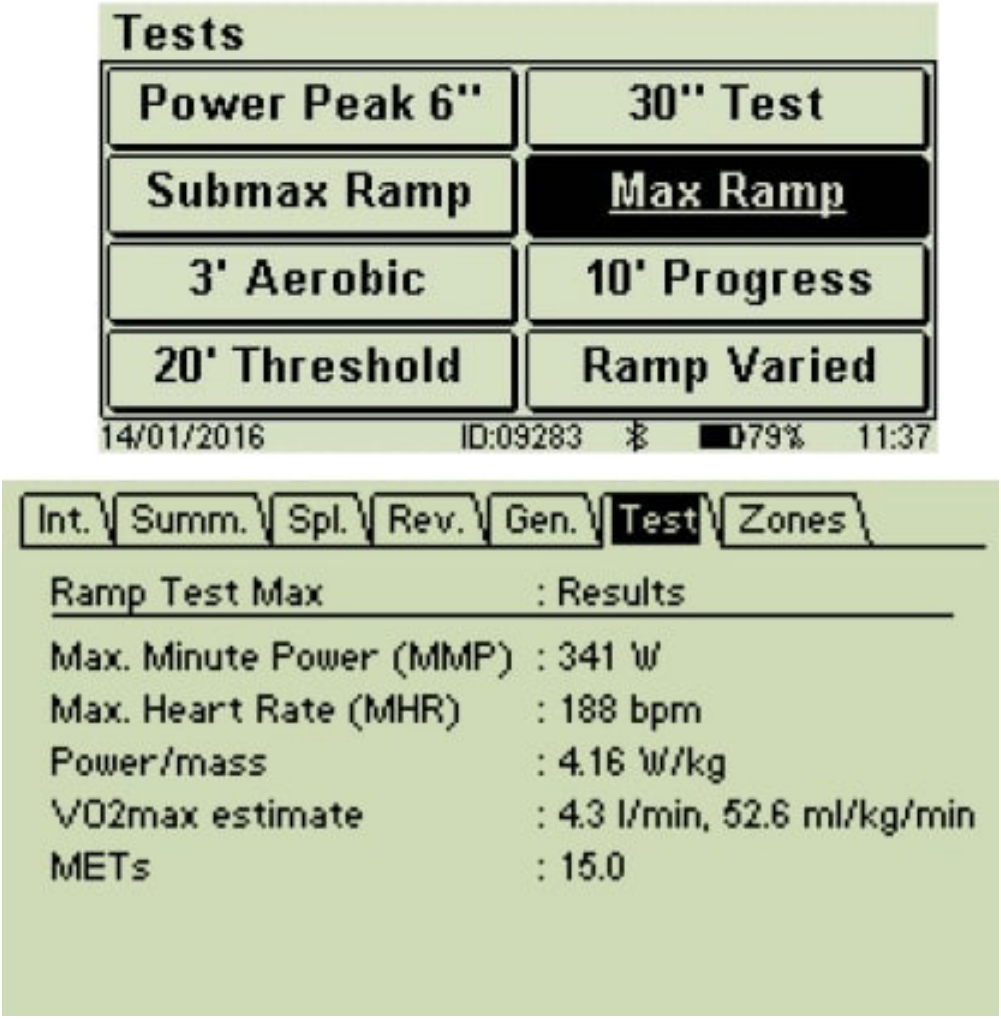

Figure. 1. Screenshots of watt bike pro Test Program

Table 1. Initial Watt Value

Initial Watt Value			
Weight (kg)	**Club Level**	**National Level**	**World Class Level**
<50	120	140	160
50-59	140	160	180
60-69	160	180	200
70-79	180	200	220
80+	200	220	240

Table 2. Watt bike 12 graded ramp test (Aerobic capacity)

Watt bike 12 graded ramp test (Aerobic capacity)												
Watts	**160**	**180**	**200**	**220**	**240**	**260**	**280**	**300**	**320**	**340**	**360**	**380**
Air Resistance	1	2	3	4	4	5	5	6	6	7	8	9
Cadence	92	89	91	89	92	89	92	90	92	91	91	91
Watts	180	200	220	240	260	280	300	320	340	360	380	400
Air Resistance	1	2	3	4	4	5	5	6	6	7	8	9
Cadence	96	93	95	93	96	93	96	94	96	95	95	95
Watts	200	220	240	260	280	300	320	340	360	380	400	420
Air Resistance	1	2	3	4	4	5	5	6	6	7	8	9
Cadence	103	98	100	98	101	98	101	99	101	100	100	100

the platform with 43 cm length, 42 cm width and 65 cm height) to identify dynamic balance stability has included two parts. Balancing board is activated in an integrated way to the system by connecting to EasyTech2.2001-2.0 computer software via USB interface. It has been transferred to analogue-digital convertor card with potentiometer via electric signals with $0,1^0$ maximum measuring error and in ± 15 slant range in stabilimeter sagittal plan. In interface of EasyTech2.2001-2.0 software, balancing score has been measured based on swinging in balance position (Figure. 2) [47]. Plastic apparat which can be adjustable as 10 cm, 25 cm and 40 cm with difficulty levels and modified in sub surface of Libra balancing board is available. 40 cm apparat has been preferred as difficulty level for the participants. Each participant has started Libra see saw balancing board with single foot by placing on balancing board especially right foot on the center at the beginning of the test. It has been provided to implement three more tries with other foot by resting for five minutes after three tries. The same protocol has been performed as both feet lateral and both feet transfer. Trying scores have been recorded [48].

Training Protocol

Test group has implemented functional training three days in a week (Monday, Wednesday, Friday) for eight weeks. In addition to functional training program, supportive classic strength training has been included twice a week (Tuesday-Thursday) between third and eighth week. Test and control groups have also participated in basketball combined technic, tactics and shot trainings twice a week within 8 weeks in the condition of its extent parallel to its intension.

A-Functional Training (1st and 2nd Week): The training program including 10 stations created by the participants has been performed circularly. After the defined station has been implemented for 30 seconds, they have switched to the other station. The participants have made the performance in all stations. Three sets have been implemented in total. 1- or 2-minutes rest between the sets and 30 seconds rest between the stations have been given. Air squat, push up, lunge, rope swinging (12 kg), skipping rope, Tire& sledgehammer (10 kg), crunch, tire flips, hyper extension, box jumps (40 cm) performances have been implemented with station method. In circular training modelling the station approach by Sperlich et al. and resting protocol have been preferred [49].

B-Functional Training (3rd and 4rd Week): The training program including 10 stations created by the participants has been performed circularly. After the defined station has been implemented for 30 seconds, they have switched to the other station. The participants have made the performance in all stations. Four sets have been implemented in total. 1- or 2-minutes rest between the sets and 30 seconds rest between the stations have been given. Burpees, Plank, box jumps (40 cm), Dumbbell Push-Up into a Row, throwing a medicine ball on the ground (5 kg), rope swinging (12 kg), crunch, superman exercise, skipping rope, TRX- rowing performances have been implemented with station method. In circular training modelling the station approach by Sperlich et al. and resting protocol have been preferred [49].

C-Functional Training (5th and 8th Week): The training program including 10 stations created by the participants has been performed circularly. After the defined station has been implemented for 30 seconds, they have switched to the other station. The participants have made the performance in all stations. Four sets have been implemented in total. 1- or 2-minutes rest between the sets and 30 seconds rest between the stations have been given. Tire & sledge hammer (10 kg), Ab Roller crunch, TRX-push up, hyper extension, throwing a medici ne ball on the ground (5 kg), skipping rope, dynamic plank, pull up, Bulgarian split squat, rope swinging (12 kg) performances have been implemented with station method. The station approach by Sperlich et al. and resting protocol have been preferred (Table 3) [49].

A-Strength Training (3th and 4th Week): The participants have implemented Back squat and dead lift movements. Suitably to traditional strength training, 3 sets with 60 percentage of 1 max turn; 10 turns have been implemented. 30-45 seconds rest between sets and 1-2 minutes rest between stations have been given (Table 3) [50].

B-Strength Training (5th and 6th Week): The participants have implemented Back squat and dead lift movements. Suitably to traditional strength training, 4 sets with 70 percentage of 1 max turn; 10-12 turns have been implemented. 60 seconds rest between sets and 1-2

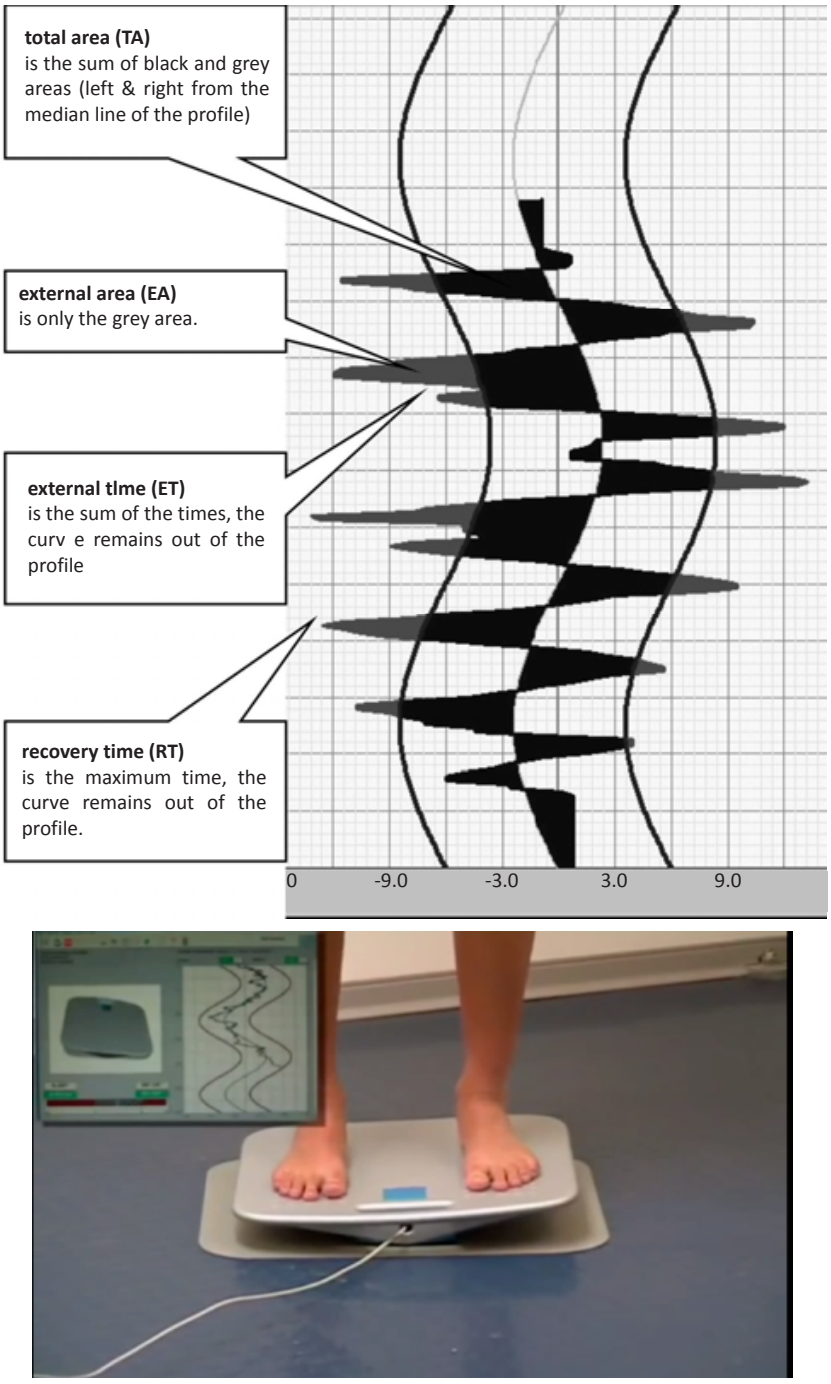

Figure 2. Libra See Saw Balancing Board.

minutes rest between stations have been given (Table 3) [51].

C-Strength Training (7th and 8th Week): The participants have implemented Back squat and dead lift movements. Suitably to traditional strength training, 4 sets with 80-85 percentage of 1 max turn; 6-8 turns have been implemented. 1-2 minutes rest between sets and 2-3 minutes rest between stations have been given (Table 3) [51].

Basketball Technical and Tactical Training (1st and 8th Week): Basketball players out of the participants in test and control groups have continued basketball trainings two days a week. Basketball training has been performed with 90 minutes period of time every day. The training has included technic drills, tactic drills, shot drills, and dribble drills. In this training structures, long HIIT (High Intensity Interval Training; 1-2; 1) and short HIIT (High Intensity Interval Training; 1; 3-6) have been implemented. In the content of training at the same time 1v0, 2v0, 3v0; ve 1v1, 2v2, 3v3, 4v4, 5v5 variations have been included (Table 3) [52].

Statistical Analysis:

The data has been prepared in MS Excel (2007) program for Windows and the graphics for the study have been drawn. The statistical analysis has been created in SPSS (17. 0) program for Windows. In repetitive

measurement variance analysis time group x interaction has been evaluated. The conditions whether the data has normal distribution or not before the hypothesis to identify the suitable test have been investigated. The significant level has been evaluated as $p < 0.05$.

Results

When obtained results have been evaluated, when comparing the difference between pre and final test average values of control group and test group in VO_{2Max} Estimate (Mg/kg/min) and Met values in group x time interaction dimension, the difference between the groups has been found statistically significant (F1, 28;p<0.05) (Table 4).

According to the results of simple effect test, while the alteration that has come out between VO_{2Max} Estimate (Mg/kg/min) and MET values in pre and final test values of test group has been found statistically significant according to results of the analysis, the change in control group has not been found statistically significant (Table 5).

When obtained results have been evaluated, when comparing the difference between pre and final test average values of test group and control group in body fat percentage values group x time interaction dimension, the difference between the groups has been found statistically significant ($F_{1,28}$;4.087;<0.05) (Table 6).

According to the results of simple effect test the

Table 3. 8 weeks Training Program

TRAINING PROGRAM						
		Days				
WEEKS		**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
1st and 2nd.	Morning	A-Functional Training		A-Functional Training		A-Functional Training
	Evening		Basketball Technical and Tactical Training		Basketball Technical and Tactical Training	
3rd and 4th	Morning	B-Functional Training	A-Strength Training	B-Functional Training	A-Strength Training	B-Functional Training
	Evening	Basketball Technical and Tactical Training			Basketball Technical and Tactical Training	
5th and 6th	Morning	C-Functional Training	B-Strength Training	C-Functional Training	B-Strength Training	C-Functional Training
	Evening	Basketball Technical and Tactical Training			Basketball Technical and Tactical Training	
7th and 8th	Morning	C-Functional Training	C-Strength Training	C-Functional Training	C-Strength Training	C-Functional Training
	Evening	Basketball Technical and Tactical Training			Basketball Technical and Tactical Training	

Table 4. VO_{2Max} Estimate Mg/kg/min and Met values group x time interaction

Group	**Measurement**	**N**	**Average. ± Std. H.**	**F**	**p**
Test	Pre test	15	35.530 ± 1.348	21.357	.000*
	Final test	15	43.800 ± 1.148		
Control	Pre test	15	37.910 ± 1.348		
	Final test	15	39.500 ± 1.148		
Test	Pre test	15	10.140 ± .386	20.035	.000*
	Final test	15	12.520 ± .333		
Control	Pre test	15	10.820 ± .386		
	Final test	15	11.350 ± .333		

*p< 0.05

Table 5. VO_{2Max} Estimate Mg/kg/min and Met values simple effect test results

Group	Measurement -1	Measurement -2	Mean Dif. ± Std. H.	p
Test	Final test	Pre test	8.270 ± 1.022	.000*
Control	Final test	Pre test	1.590 ± 1.022	0.131
Test	Final test	Pre test	2.380 ± .292	.000*
Control	Final test	Pre test	.530 ± .292	0.08

*p< 0. 05

Table 6. Body Fat Percentage Values group x time interaction

Group	Measurement	N	Average ± Std. H.	F	p
Test	Pre test	15	14.960 ± 1.118	7.901	.009*
	Final test	15	14.516 ±1.037		
Control	Pre test	15	11.273 ± 1.118		
	Final test	15	11.272 ± 1.037		

*p< 0. 05

Table 7. Body Fat Percentage values simple effect test results

Group	Measurement (1)	Measurement (2)	Mean Dif. ± Std. H.	P
Test	Final test	Pre test	-.443 ± .111	.010*
Control	Final test	Pre test	-.001 ± .111	.992

*p< 0. 05

alteration that has come out between Body Fat Percentage pre and final test values has been found statistically significant according to results of the analysis. However, no significant change in control group has been identified (Table 7).

When obtained results have been evaluated, when comparing the difference between pre and final test average values only in left foot lateral balance scores group x time interaction dimension, the difference between the groups has been found statistically significant (F1, 28;4, 320; p<0,05) (Table 8).

According to the results of simple effect test, while the alteration that has come out between pre and final test in right lateral balance and Both Feet Lateral Balance in test group has been found statistically significant, the alteration between pre and final test values in all balance values in control group has been found statistically significant according to results of the analysis (Table 9).

Discussion

In this study, while the developmental difference in VO_{2Max} Estimate (mg/kg/min), MET, body fat percentage and left foot lateral balance test values in both test and control groups when comparing group x time interaction has been found statistically significant, no significant difference has been found in both feet lateral balance, right foot lateral balance and both feet transfer balance measurements. When examining pre and final measurement values of simple effect test group directed to the effect of training, while the difference in VO_{2Max} Estimate (mg/kg/min), MET, body fat percentage, both feet lateral balance and right foot lateral balance values has been found significant, no significant difference in left foot balance and both feet transfer balance values has been found. When pre and final measurement values of control group have been examined, while significant difference has been found in both feet lateral balance, right-left foot lateral balance and both feet lateral balance values, no significant difference has been found in VO_{2Max} Estimate (mg/kg/min), MET, body fat percentage values.

Shaik and Mondal in their study have stated that functional training has improved speed, endurance, strength, explosive strength, flexibility and agility [5]. Neves et al. on their study implemented on women have stated that there is a development in oxygen capacity of circuit HIIT group at the end of 9 weeks Circuit combined and Circuit HIIT trainings [53]. Kibele and Behm have defined that 7 weeks functional training is similar to aerobic development at the end of traditional resistance training program [54]. Kliszczewicz et al. in their research have stated that there is an improvement in aerobic capacity after 4 weeks high intensity mixed mode programed resistance and aerobic based exercise [55]. Many research findings have pointed out that Circuit HIIT training model has developed VO_2 Peak parameters [49, 56]. Current literature findings show parallelism with our research findings.

Tomljanović, et al in their study have identified that there is no difference in either of two training models in anthropometric after 8 weeks functional and resistance

Table 8. Group x time interaction according to balance test values

Test	Group	Measurement	N	Average. ± Std. H.	F	p
Both Feet Lateral Balance	Test	Pre test	15	8.930 ± .582	1.596	0.217
		Final test	15	6.320 ± .593		
	Control	Pre test	15	12.900 ± .582		
		Final test	15	11.090 ± .593		
Right Foot Lateral Balance	Test	Pre test	15	6.860 ± .555	0.019	0.891
		Final test	15	5.290 ± .547		
	Control	Pre test	15	10.380 ± .555		
		Final test	15	8.740 ± .547		
Left Foot Lateral Balance	Test	Pre test	15	6.230 ± .473	47.641	0.010*
		Final test	15	6.120 ± .529		
	Control	Pre test	15	10.140 ± .473		
		Final test	15	8.050 ± .529		
Both Feet Transfer Balance	Test	Pre test	15	9.630 ± .725	1.031	0.319
		Final test	15	8.980 ±.676		
	Control	Pre test	15	10.940 ± .725		
		Final test	15	9.460 ± .676		

*p< 0.05

Table 9. Simple effect test results according to balance test values

Test	Group	Measurement -1	Measurement -2	Mean Dif. ± Std. H.	p
Both Feet Lateral Balance	Test	Final test	Pre test	-2.610 ± .448	0.000**
	Control	Final test	Pre test	-1.810 ± .448	0.000**
Right Foot Lateral Balance	Test	Final test	Pre test	-1.570 ± .357	0.000**
	Control	Final test	Pre test	-1.640 ± .357	0.000**
Left Foot Lateral Balance	Test	Final test	Pre test	-.110 ± .506	.830
	Control	Final test	Pre test	-2.090 ± .506	.000**
Both Feet Transfer Balance	Test	Final test	Pre test	-.650 ± .578	.270
	Control	Final test	Pre test	-1.480 ± .578	.016

*p< 0.05

trainings [57]. They have stated that decrease in the measurements of traditional training group and increase in functional training group have been observed. The decrease in traditional group has been explained with the high intensity of training. Serin and Ziyagil have expressed that there is a decrease in a significant level in body fat percentage values in men after 8 weeks squat exercise program [43]. Neves et al. in their study conducting 8 weeks functional training implementations in Circuit format on female participants have seen that there is a decrease in body mass index and fat rates [53]. Doğan et al in their study implemented on 18-30 years old football players have stated that significant decrease in body mass index and body weight values of test group compared to control group after 8 weeks core training [58]. Heinrichet al have expressed that there is no significant alteration in body fat percentage values for both groups after 8 weeks high intensity functional strength training and medium level aerobic strength training implementations [59]. When literature has been examined, the studies conducted by Serin and Ziyagil, Neves et al and Doğan et al. show parallelism with our study [43, 53, 58]. However, the studies by Tomljanović, et al and Heinrichet al have not been supporting [57, 59]. When considering the content and duration of functional trainings, it has been thought the effect of body fat percentage will be more effective.

Whitehurst et al have stated that functional training model in balance development is numerically better than traditional training [60]. Kibele and Behm have pointed out that 7 weeks functional training is similar to dynamic balance development after traditional resistance training program [54]. Vreede et al have expressed that leg strength, balance and coordination have improved with 12 weeks functional training.

Pacheco et al in their study in which they researched the effect of functional training on balance have identified that there is a significant improvement in balance values of the individuals who have the average (54.75 ± 8.84 years) [62]. Oliver and Brezzo in their study have stated that improvement in balance scores has been observed after functional balance training for collegiate female volleyball players and football players in both groups [17]. Boztepe and Erkut in their study conducted with active football players have identified that the increase in balance values of functional training group is in a significant level compared to traditional training group [63]. In also current literature findings, it has been exhibited that functional training develops not only strength and resistance but also flexibility, balance, coordination and deep sensory and besides it is an effective training model in terms of empowering the performance [64-67]. When literature findings have been examined, increase in balance values has been seen in the studies where functional training model is used. The research supports our results. In view of group x time interaction, while left foot lateral dynamic balance shows development in both groups, it has been seen that both feet lateral and right foot lateral dynamic balance have been affected in a positive way in test group in simple effect. That there are more movement combinations towards lateral side rather than transfer side in basketball branch and there is more pressure on single foot when performing technics such as turnstile for scoring to basket bring balance concept into the forefront.

Conclusions

In functional training approach, it has been thought that the efficiency will be increase on the condition of its compatibility with the technic values of sports branch. It has been seen that placing functional trainings in basketball yearly training periodizing will contribute to aerobic power, balance and body fat percentage values. Increasing in anaerobic capacity has been affecting aerobic capacity at the same time. The efficiency of balance technics in contributing to game scores is important.

Conflict of interest

Authors declare no conflict of interest.

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The relationship between the motor skills level and the severity of autism disorder in children with autism

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Abstract

Purpose: This study aimed to determine the relationship between the level of fine and gross motor skills and motor proficiency with the severity of autism disorder in children with autism.

Material: 68 children with autism, ranged from 3-16 years old, were selected. Motor Assessment Battery for Children-2 (MABC-2) was used to assess fine and gross motor skills and motor proficiency. Gilliam Autism Rating Scale-2 (GARS-2) test was also used for assessing the severity of autism disorder in the participants.

Results: The obtained results from the Pearson correlation test showed that there was a significant and negative relationship between sub-scales of GARS-2 and MABC-2 tests ($P<0.05$). It means that decreasing the level of motor skills increases the autism severity. The results of the regression test also showed that only the total score of motor proficiency among microscales of the MABC-2 test could predict the stereotypes, social skills, communication skills, and autism severity ($P<0.05$).

Conclusions: The results of the current study indicated the pivotal role of motor skills growth in determining the level of autism disorder. It also emphasized on embedding motor interventions in rehabilitation programs of such people.

Keywords: autism, motor skills, fine motor skills, gross motor skills

Introduction

Autism spectrum disorder (ASD) is one of the developmental disorders with symptoms of deficit in social communication and interaction with others and stereotypes in the person [1]. Although the main feature of this disorder includes the deficits of social relationships, there are many pieces of evidence, indicating that children with autism have different levels of motor skills deficits as well which cannot be described by mere neurocognitive mechanisms [2]. Motor deficits, mostly seen in people with autism, include delay in fine and gross skills development [2-4], the deficit in walking such as differences in joint angles and forces on the ground [5], postural instability because of the problem in sensory processing [6] and the problems of coordinating the motor organs in planning and implementing the movement [7]. Such motor deficits are even observable in early birth ages before age one for delay in fundamental motor skills [8]. Because the etiology of autism spectrum disorder is not clear yet, the role of motor skills in this disorder is not well known.

The complementary development theories assume about the normal children that the growth of all person's aspects depends on the interaction between different growth ranges. For example, the embodiment hypothesis of the dynamic system theory argues that growth aspects never grow alone [9]. Yet, growth changes form as the result of interaction between the environment and motor-perceptional experiences. Therefore, a child's motor experiences can affect the growth of other aspects of him such as cognitive, social, and relational. The supporting evidence of this theory can be seen in normal people and even those with other growth disorders such as Cerebral Palsy [11]. For example, normal children in kindergarten, having higher motor skills, participate in group games, and have less social problems with other kids [10]. In children with Cerebral Palsy, the level of motor growth predicts their social performance [11].

The studies about motor skills in people with autism are not clear. It is shown that gross motor skills growth has a relationship with disorder symptoms in children [12] and adolescents [13] while others did not find any relationship between these fields in 4-12.5-year-old people [14]. The contrast in findings might be due to differences in the methodology of previous studies. No significant difference was seen in a study, conducted with a high volume of samples while many children showed a high level of motor skills due to the ceiling and floor effects in the gross motor skill assessment tool [14]. Different findings have been reported in the case of the relationship between gross motor skills and social skills [14-16]. Most of the studies, which have shown a low relationship between social skills and motor growth, have been conducted in the societies, whose participants had been in childhood. Whereas the wider age range showed a better perception of the rate and form of relationship between motor skills and social skills in people with autism. Pusponegoro et al [15] reported lower motor skills in 1,2,3- year-old children with autism in comparison with normal ones though they only assessed the relationship between motor and social skills in the group.

The current study aimed to determine the relationship between the level of fine, gross motor skills, and motor proficiency with related components to autism disorder in

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children of 3 to 16 years old. The reason for choosing this range of age was the comprehensiveness of the studied sample and better determination of the relationship between the variables in the age range and growth period. It was also tried in this study to investigate the predictability of autism disorder level based on the level of motor skills.

Material and Methods

Participants

In order to conduct this study, 68 children with autism in the age range of 3 to 16 years old (mean=8.27, standard deviation=3.20) were chosen and investigated through referring to educational and rehabilitation centers for children with autism in Mashhad. The inclusion criteria of the study were confirmed autism disorder by the psychiatrist, no simultaneous disorders and diseases such as hyperactivity, mental retardation, structural, musculoskeletal deficits, no cardiovascular diseases, and epilepsy. After being briefed about the study, all parents signed the conscious consent forms.

Instruments

Gilliam Autism Rating Scale-2 (GARS-2)

This questionnaire is one of the most common tools for assessing ASD with 42 items, which assesses three fields of stereotypes, social skills, and communicational skills in a person. The score of each item ranges from 0 to 2 so that score 0 is rarely, 1 sometimes and 2 most of the time. The highest score in each sub-scale is 42 and the lowest one zero. Higher scores indicate more severity. In the end, participants were divided into three levels of autism with a probability of very low, average, and high [17]. The test can be used for the ages 3 to 22 and shall be completed by a person who is aware enough about the participant such as parents or teachers. The main version of this test has been tested and standardized on 1092 American and Canadian children, adolescents, and adults. According to the different studies, the reliability of the test, calculated by Cronbach's alpha, has been obtained 0.9 for stereotypes, 0.89 for communicating, 0.93 for social interaction, and 0.96 for autism symptoms. The Persian version of this test was validated by Ahmadi et al. (2011) and showed that Cronbach's alpha in stereotypes is equal to 0.74, 0.92 in communicating, 0.73 in social interactions, and 0.89 as total score [18].

Movement Assessment Battery for Children- Second Edition (MABC-2)

MABC-2 is one of the most used tests of assessing and diagnosing motor disorders in children. It proposes three components of fine, gross motor skills and total score of motor proficiency of the person [19]. It has a specific norm and is used in the age range from 3 to 17. The test is the result of two decades of studies by Henderson et al. [1] and includes three age groups of 3-6 years old, 7-10 years old, and 11-17 years old. The test includes a checklist and descriptive instruction for identifying children with motor coordination disorder. Implementing the test includes a series of fine and gross motor tasks. The tasks are grouped in three parts; 1- manual dexterity skill (including the skills of inserting pins, threading and drawing the maze), 2- targeting and throwing skill (including the activities of catching and throwing the ball and bin sack) and 3- balancing skill (including one-food standing, walking on the heel of the toe and hopscotch). The total time of the test is around 2- to 40 minutes [19]. Akbaripur et al. [20] have validated it in Iran. On this basis, Cronbach's alpha was obtained as 0.843.

The method of implementation

After checking with the centers and participants' parents, the selected children were evaluated by motor behavior experts using the MABC-2 test one by one. The test was conducted in a calm condition with the cooperation of children's trainers in their educational place because the new conditions affect participants' performance. The children's parents and trainers also responded to the GARS-2 questionnaire. The raw scores of both tests were converted to standard scores and related coefficients by the experts and using related norms and instructions and they were utilized in statistical analysis.

Statistical Analysis

To determine the relationship between the variables, the Pearson correlation test was used. to determine the predictability of participant's autism rate scores from their motor skill scores, linear regression was also used. All statistical tests were conducted by SPSS-23 software at a statistical level of α=0.05.

Results

Table 1 shows the study participants' cognitive demography.

The obtained results of the current study showed that 4.3% of the participants were in the green zone, 2.9% in the yellow zone, and 92.9% in the red zone in terms of motor skills growth. The results indicated the high prevalence of motor deficits in such people. in terms of the severity of the disorder, given the results of Garza test-2, it was also seen that 2.9% of participants are likely to have mild autism, 21.4% average autism, and 75.7% high autism.

The obtained results from the Pearson correlation test (table 2) indicate the significant relationship between microscales of GARS-2 test and fine skills ($P<0.05$), gross skills ($P<0.05$), and total score of motor skills of children with autism ($P<0.05$). The rate of such relationships can be seen in figure 1.

Multilinear regression was used to determine the possibility of predicting autism coefficient from motor skills, the results of which can be seen in table 3.

As indicated in table 3, the regression model has been signified. Index R^2adj also shows that microscales of fine, gross skills and motor proficiency can predict autism level for 37%. It was also observed that among the variables of fine, gross motor skills and motor proficiency, only the motor proficiency can predict autism level in the participants.

The obtained results from table 4 show that motor proficiency with a regression weight of -0.85 can predict autism level. The negative amount of this coefficient

Table 1. Participants' demography

Variable	Minimum	Maximum	Standard deviation	Mean
Age	3.10	16.80	3.20	8.27
Stereotypes GARS I	4	17	2.88	8.77
Communicational skills GARS II	4	19	3.52	9.70
Social skills GARS III	4	16	2.72	8.77
Autism level	66	151	17.65	96.61
Fine skills	1	9	1.96	3.41
Gross skills	2	22	4.86	6.67
Motor proficiency	6	66.5	15.18	28.72

Table 2. The results of the Pearson correlation test

Microscale	Fine skill		Gross skill		Motor proficiency	
	r	Sig	r	Sig	r	Sig
Stereotypes	-0.372	0.0001	-0.570	0.0001	-0.613	0.0001
Communicational skills	-0.413	0.0001	-0.460	0.0001	-0.530	0.0001
Social interaction	-0.436	0.0001	-0.557	0.0001	-0.610	0.0001
Autism coefficient	-0.492	0.0001	-0.519	0.0001	-0.629	0.0001

Table 3. Regression analysis of predicting autism level from motor skills

Model	Total squares	Degrees of freedom	Mean squares	F	R	R^2	R^2_{adj}	Sig
Regression	8631.04	3	2877.01	14.75	0.634	0.402	0.374	0.001
The remained	12865.5	66	194.93					
Total	21496.5	69						

Table 4. Standard and non-standard coefficients and inserted t-statistic in the regression model

Predictor variable	Regression coefficients		T-statistic	Sig
	B	Beta		
Fixed amount	118.26		31.70	0.001
Fine skill	0.651	0.073	0.377	0.707
Gross skill	0.715	0.197	0.772	0.443
Motor proficiency	-0.997	-0.858	-2.44	0.017

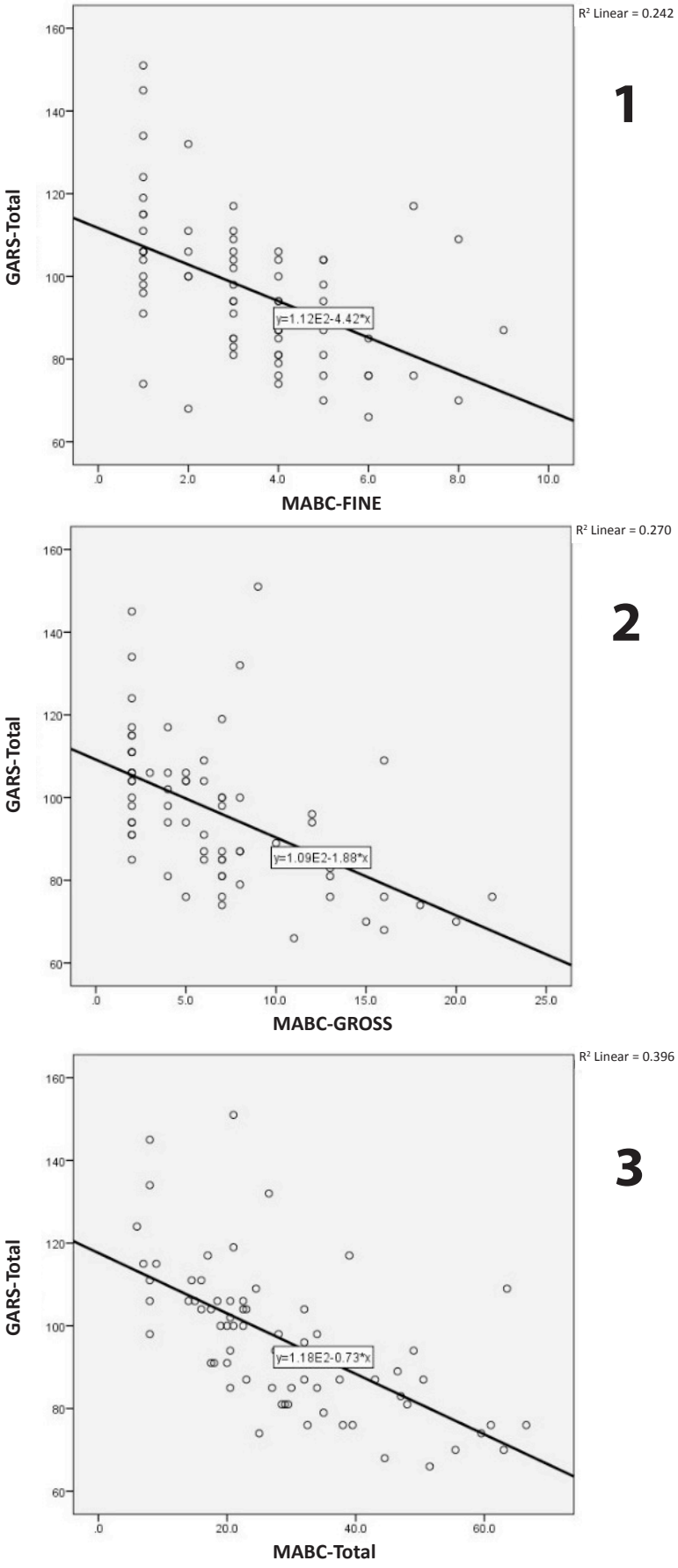

Figure 1. The fitness of correlation in fine skill and the severity of autism disorder (1), gross skills and the severity of the disorder (2) and motor proficiency and the severity of the disorder (3)

indicates that increasing the level of motor proficiency decreases the autism level of the participants.

Discussion

The results of the current study are consistent with the previous ones, indicating a significant relationship between the level of motor skills and social skills [15, 21]. Pozonger and [15] showed that children with autism who had lower motor skills showed lower social skills as well. Modi et al. [21] showed that gross motor skills have a relationship with social interaction though they did not observe the quality of communicational social relations. Hirata et al. [16] reported an average but not a significant correlation between motor skill and social performance of 7-16-year-old children with autism. Whereas, the relationship has been signified in the current study which can be because of the manner of early intervention of parents and concentrating on early treatments on their children.

The previous findings of the relationship between social skills and motor deficits are also consistent with the findings of the current study. The important point of these findings is the relationship between all three indicators of fine, gross skills and motor proficiency in children with autism. It has been also shown that weak performance in the tasks, requiring visual feedbacks such as receiving the ball or static balance, has been different in children with autism from those children with hyperactivity and attention deficit [3]. Moreover, people with autism have different visual information in comparison with normal people [6] which can be a reason for their weaker performance in such tasks. The existing tasks in microscale of manipulating the things and the balance of the MABC-2 test include knocking, grabbing, and standing on one foot. As a result, in addition to problems of visual processors, the weaker performance in such fields is likely justified by other motor components such as balancing or motor coordination.

The relationship between gross motor skills and the severity of disorder was also consistent with previous studies, showing that children with severe autism are weak in gross motor skills [12]. Interestingly, some studies have found out that the total level of gross motor skills is not related to the severity of autism and the deficit in some specific skills such as controlling the thing [22] and postural stability [13] had a relationship with autism. In the investigation of the relationship between combinational motor skills and social performance with autism severity, no significant relationship was seen [14]. One of the probable reasons for the difference between their study with the current one can be the difference in age range and tools of assessing motor skills or the severity of autism disorder.

It was also shown in the current study that the motor proficiency level of children with autism may predict the severity of the disorder in them. It might be because when the child can keep his postural stability balanced, he has to involve high physical and mental resources in processing his postural appropriate status so less capacity will remain for other resources such as social participant. Ajzenman et al. [22] observed an improvement in controlling the posture and following that in social communication after horse treatment intervention. They concluded that improving motor-perceptional abilities may create a tendency in the child for making social relationships [22]. Similarly, the ability to throw or hit a ball requires visual feedback and perceiving and predicting others' social responses. It is generally assumed that ball skills, given their nature, have a relationship with social performances [23].

The idea of the relationship between motor abilities and other growth aspects may be highly used in therapeutic interventions. It is suggested that motor interventions can be beyond the improvement of mere motor skills. Improving motor skills in children with autism may improve social skills and their other capabilities. The International Classification of Function Model encourages the disability of providers for a comprehensive image of disability, involving numerous effective factors on the total participation of the person [24]. While it cannot be certainly said that weakness in balancing or ball skills is the reason for social skills deficit in people with autism, the interventions, concentrating on the improvement of such abilities, might improve social skills in the people of this society. Previous interventions such as horse therapy, water therapy, or the motor skill-based approaches have shown some benefits for socializing [23, 24]. Although further studies are needed, the findings of the current study suggest that motor skills have a relationship with the main symptoms of autism and shall be considered in the interventions. Moreover, the current study suggests that the experts of different fields shall consider the creation of motor status for growing other related growth fields with autism. Similar to most children with growth disorders, the complicated nature of autism requires a team approach, in which all team members cooperate to design an appropriate program.

Conclusion

The current study showed that there is a relationship between motor skills and ASD symptoms. The participants' motor proficiency scores could predict their autism level. The motor ability of people also changed given the severity of the disorder. The later studies shall investigate the effect of motor interventions on the improvement of related capabilities to autism disorder.

Conflict of interest

Authors declare no conflict of interest.

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