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REVIEW ARTICLE

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Effects of yoga training in post-menopausal women

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Abstract
Aging is a multietiological process and a major risk factor for chronic diseases including geriatric. In the healthy aging, the proper implementation of exercise to improve disease-related symptoms and comorbidities in the general population is a high priority. However, there is still a gap concerning studies analyzing influence of yoga in older people especially in post-menopausal women. Therefore, the aim of this mini review is a brief summary of well-established findings in yoga as an exercise intervention. In this paper, we conducted a narrative mini review of the influence of practising yoga on aging especially in post-menopausal women, searching the online databases: Web of Science, PubMed and Google Scholar, and, subsequently, discuss possible mechanisms of this action. On the basis of this review, it is evident that practising the yoga seems to be a promising intervention especially recommended for the elderly.

KEYWORDS: BDNF, training, yoga, neurotrophic factors, post-menopausal women.

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Introduction

Yoga is one of the few systems that were developed more than 1,500 years ago and have survived to the present day. It was developed to promote health, wellness and preventive health care. Yoga is a system of posture exercises aimed at self-discipline of the body and its proper functioning. It is a myofascial system that ensures the cooperation of anatomical bands, and because it is connected with the breath, it nourishes specific regions of the body. The precision of movements (aiming at reflecting the pattern of a given position (asana) established by the creators of yoga is aimed at focusing attention on the exercise without being distracted by external stimuli, favoring the achievement of a positive breathing pattern.

The effect of yoga training in elderly people is, currently, a frequently subject of research. Developed studies point to its positive influence on the human body and psyche and, among them, psychophysiological changes have a beneficial effect on how the circulatory and respiratory systems work, improving its efficiency within a few months from starting yoga practice [7, 13, 17]. Changes in cognitive functions are also seen [8, 11, 12, 14, 15, 16]. Moreover, it was also proven that during a 3-month isolation period with yoga, a reduction in the severity of anxiety was noticed as well as an increase in mindfulness correlating with an increase in plasma BDNF levels [1, 10]. The percentage of elderly people suffering from depression is growing rapidly worldwide. Yoga practices are associated with antidepressant effects, an increase in serum BDNF levels, and a decrease in serum cortisol levels [1, 2, 5, 11, 15]. Thus, to help create a demand-driven system, we would like to look at the changes accompanying yoga practice in women over 60. Research conducted by numerous teams proves that in consequence of appropriate training, it is possible to improve the functioning of the elderly. However, this requires precise arrangements that would enable them to engage in appropriately designed exercises and adjust them to the health condition of exercising seniors.

The aim of this mini review is analysis of the influence of yoga on the physical fitness and cognitive abilities of post-menopausal women. The following issues seem to be the most interesting in the answering the question if yoga leads to (i) improvement in the levels of circulatory and respiratory fitness in postmenopausal women (ii) improvement in mental state of the respondents, including a reduction in depression severity and an increase in concentration of selected neurotrophins in blood, (iii) favourable metabolic changes; improvement of lipid profile, better glucose tolerance by regulating the secretion of hormones controlling metabolic changes.

Neurotrophic factors

In studies on yoga effects on cognition, concentration of brain-derived neurotrophic factor (BDNF) is usually analyzed. However, to our knowledge, the protein Glial cell line-derived neurotrophic factor (GDNF) is usually not included. Therefore, many authors analyse, both the concentration of GDNF, BDNF, growth factors (VEGF-A, IGF1) and selected muscle myokines (FNDC5). This knowledge contribute to developments of the field and scientific discipline, as by studying cognitive functions, cardiovascular and respiratory efficiency in postmenopausal age as well as the concentration of selected neutrophins in the blood under the influence of yoga training, it will help to better understand healthy aging processes.

Normally researchers include a biochemical test before and after the intervention. The combination of physical exercises (yoga) and breathing exercises (pranayama) allow to optimize the health-promoting effects of yoga in elderly people. Thus such analysis are addressed at the elderly for the sake of their physical health, cognitive functions and mental well-being, hence healthy aging.

During late adulthood, certain areas of the brain are atrophied. This contributes to the deterioration of cognitive functions and increases the risk of depression. There is scientific evidence that aerobic exercise can improve learning and memory functions, improve mood and prevent neurodegenerative changes [3]. Impaired BDNF function may be involved in the etiopathogenesis of the metabolic syndrome. BDNF plays a fundamental role in the development and survival of neurons, it is a real modulator of brain plasticity, influencing cognitive functions [6]. The concentration of neurotrophins depends on many factors and interventions. Among the scientific publications, the factor affecting the concentration of neurotrophins is physical exercise, including the practice of hatha-yoga. An important element of the research is the demonstration of the effect of 8-week yoga training on the concentration of neurotrophins depends on many factors and interventions. Among the scientific publications, the factor affecting the concentration of neurotrophins is physical exercise, including the practice of hatha-yoga.

Selected studies have shown that physical exercise has an impact on the cognitive functions of the brain [9] and the practice of yoga as a combination of elements of work with the body and psyche affects the cognitive functions of the brain [8]. It has been shown that people suffering from depression are characterized by a low level of BDNF and an increased level of cortisol in the serum. The practice of yoga is associated with antidepressant effects, an increase in serum BDNF levels, and a decrease in serum cortisol levels [1, 11, 15].

Yoga as an intervention

Research conducted by many teams proves that, as a result of appropriate training, it is possible to improve the functioning of the elderly, but it requires precise arrangements that would entitle them to recommend appropriately designed exercises and adjust them to the health condition of exercising seniors. Pro-health training of elderly people is a special area of activity on the borderline of health prophylaxis, rehabilitation and even sports, because the elderly are much more diverse in terms of physical, cognitive and emotional condition, and are in different health conditions than young or average people century.

Based on our previous observations and analyzes, we suggest to introduce older people to the training in order to maximize the impact of training on the largest possible number of structures and processes of the exercising person. The most important elements taken into account in the exercise include muscle training to prevent sarcopenia and improve efficiency, functional fitness and gait quality, cognitive training as a prevention of premature aging of the central nervous system, expected increase in quality of life.

We expect that the combination of exercises designed according to the concept described above in one training unit may be associated with a well-proven slowing down of sarcopenia progressing with age, and an increase in general condition and functional fitness, on the other hand, with an increase in mental well-being.

The preliminary theoretical analyzes carried out for the purpose of the application provided the foundations justifying the design of a training model for the elderly and the development of future recommendations for training the elderly. However, there are few reports of the metabolic basis of changes in CNS function under training conditions. We assume that post-training affective changes may be associated with an increase in the blood level of BDNF and GDNF and other indicators of exercise metabolism. In the light of numerous studies on the level of BDNF, there is little information regarding the influence of exercise training on the level of GDNF in humans. More extensive animal studies, mainly rodents, provide data on GDNF levels in the hippocampus of stressed rats, Parkinson's disease mice, and spinal cord and skeletal muscle in response to exercise. The direction and size of changes in the concentration of neurotrophins depend on the duration of training, its intensity, the type of exercise performed and the health condition of the respondents [3].

Contrary to typical endurance training, the beneficial effects of which are the result of metabolic changes related to muscle work, yoga with music additionally stimulates the brain by increasing the secretion and transport of dopamine. This neurotransmitter conditions learning processes, affects our motivation and mood, and stimulates neurogenesis. The action of these neurotrophins influences the function of serotonergic and dopaminergic neurons. Exercise of an appropriate intensity and duration causes the occurrence of metabolic changes in the muscle, where we observe an increase in the secretion of growth factors (VEGF), insulin-like growth factor (IGF 1), interleukin-6 (IL-6) and adipomokines [4]. Thus, a huge influence of metabolites of muscle origin on the expression of the BDNF gene in the hippocampus and angiogenesis in the CNS was demonstrated. The effect of muscle activity on the life expectancy and plasticity of neurons, observed in numerous studies, may be a non-pharmacological method of treating and preventing depression and other diseases related to neurodegeneration in the course of the aging process [8, 11].

The theoretical background was based on the interventions proposed by Suzuki et al. [21], applied/administered to people diagnosed with mild dementia. The proposed intervention aims to stimulate physiological processes in the musculoskeletal system, and consequently also affect the overall efficiency of the body, but also mobilize cognitive processes. The above-mentioned processes should, in effect, also affect such parameters of physical health as circulatory and respiratory parameters, cardiovascular parameters, gait quality, psychomotor parameters, neuroplasticity of the central nervous system, quality of life, functioning of cognitive processes, general health. In addition, based on our preliminary observations, an attempt should be made to include in the intervention a combined training model understood as a combination of physical, cognitive and mindfulness exercises in one training unit, as a training strategy for influencing the healthy aging process. It is worthy to examined whether the applied yoga training positively mobilizes the body and mind of a senior and has a positive effect on the health parameters and functioning of the body of people aged 60-75 years.

Observations suggest that yoga practices can be used as psychophysiological stimuli to increase endogenous melatonin secretion, which in turn may be responsible for improving well-being.

Another important parameter is cortisol, it plays a key role in maintaining the hormonal balance of the body, the reduction of which contributes to better well-being, cognitive functions, and maintaining the balance of hormones. In many scientific publications, after the intervention of yoga, a decrease in the level of cortisol in saliva, a decrease in blood glucose levels along with a decrease in the level of plasma renin and the level of norepinephrine and adrenaline during the day are shown [19, 20].

The hypothalamic-pituitary-adrenal axis (HPA) is an endocrine system consisting of numerous structural and functional interrelationships between the hypothalamus, pituitary gland and adrenal gland [18].

Due to the negative feedback in this system, there is a constant exchange of information. The HPA axis plays an important role in the processes of adaptation and the body's response to stress. The hypothalamic-pituitary-adrenal system coordinates the secretion of glucocorticoids (such as cortisol) from the adrenal cortex into the blood, thereby preparing the body for a fight-or-flight response. In addition, the HPA axis is involved in regulating emotions, mood and sexual behavior. The activity of this system depends on the action of neurotransmitters of the nervous system.

Benefits

Benefits might be expected for the respondents both in the physical and mental aspect and, consequently, it may lead to the achievement (gaining) of an increase in a positive attitude to life and a positive feeling of quality of life (Thirthalli). The preliminary theoretical analyzes provided the foundations justifying the design of a training model for the elderly and an attempt to develop future training recommendations for the elderly beyond the parameters of intensity, volume and weekly frequency, including cognitive and mindfulness elements in one training unit.

The importance of yoga training programmes results for the development of a given field and scientific discipline. On the basis of the obtained research results – a new, alternative exercise program for the elderly, due to the nature of low-intensity exercises performed during yoga classes, they are recommended to be performed by the elderly. It is possible to perform exercises in elderly people with low body efficiency, which have a positive effect on the overall improvement of health. During yoga practice, the practitioner learns, among others: proper breathing, increases the range of mobility within the spine, lower and upper limbs, strengthens and tones the body, preventing the risk of falls, improving the correct gait function, contributing to the reduction of hospitalizations. The pelvic floor muscles are strengthened, the strengthening of which is a prevention of stress urinary incontinence. By stimulating the muscles, yoga training influences the secretion of neurotrophic factors, stimulating neurogenesis in the hippocampus, thus preventing dementia and cognitive decline in the elderly.

Summarizing, yoga seems to be a promising intervention especially recommended for the elderly.

Conflict of interest

The authors declare no conflict of interest.

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ORIGINAL ARTICLE

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Physical activity, physical fitness and cognitive function in adolescents

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Abstract
Introduction. Physical activity (PA) brings cognitive, mental and physical improvements in adolescents, benefiting physical fitness (PF), cognitive results and mental health. Aim of Study. The present study aimed to analyze and characterize the level of PA, PF and attention in adolescents. Material and Methods. A descriptive cross-sectional study was performed. Forty-three adolescents aged 16 to 18 years old (16.77 ± 0.61 years), where 53.5% (n = 23) were boys participated in the study. An international questionnaire was used to accessed PA and PF levels. The CAD-S Assessment Scale revised version was used to evaluate the level of attention. Standard statistical methods were used to calculate means, standard deviations, and chi-square test. Results. The results show a moderate level of PA practice in adolescents (60.5%) and a high level of PA in boys, whom have also a good perception of their PF level 53.5% ($p \leq 0.05$). In the attention capacity, high levels in the adolescents (79.1%) were observed. Conclusions. The adolescents have a good perception of their PA and PF levels, showing positive perception on cognitive function. The practice of PA daily at school and extracurricular contexts seems to be essential to obtain high levels of PF and attention, contributing to better academic performance and life quality.

KEYWORDS: concentration, attention, school, teens, exercise.

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Introduction

The regular practice of physical activity (PA) shows a positive association with the health of adolescents and can be a factor promoting change to an active lifestyle [3]. Moderate to vigorous intensity of PA is frequently suggested for health benefits [1, 28]. PA is characterized by any body movement produced through skeletal muscles that requires energy expenditure [3]. Literature suggests that individuals regularly practicing PA are less likely to have health problems [23], with research results confirming that it provides several health benefits e.g. to young people [2, 6, 20]. The relationship between PA practice and development of adolescents is of great interest, because it is an important phase to establish good healthy living habits, which can be further maintained during adulthood [17]. Previous researches also showed that PA and good physical fitness (PF) levels could support cognitive function and attention capacity both in children and adults [4, 13, 22].

In this sense, it seems to be important to develop motivating and effective programs, which value PA practice, producing benefits in PF, attention capacity, and even personal and social growth of adolescents [1, 25].

The PF defined as the ability to perform daily tasks with vigor and enough energy to enjoy the activities without fatigue [3], is considered a health factor improving the life quality of adolescents [9, 19]. High levels of PF in adolescents have been associated with more advantages, such as health-related outcomes regarding cognition and academic performance through psychological, physiological and learning methods [22]. Recently, PF has attracted great interest of teachers, parents and researchers, due to its positive influence on the cognitive function and academic performance [18, 24].

The cognitive function, especially attention, is a fundamental and determinant aspect when performing tasks or physical exercise for a long period of time, having a positive and significant relationship with vigorous PA and PF [29]. Attention can be described as a cognitive function defined by the behavioral and cognitive process of concentration in a task without the environment disturbances [29], but also involved in processes of activation and selection, distribution and maintenance of psychological activity [11]. A strong relationship between PA and the cognitive function has been reported, where better learning and development of attention skills in young people are accomplished [6, 10, 12, 14, 25, 27].

Although the relationship between PA and variables such as attention and PF is relatively well-known in adults [12], there is a lack of studies characterizing and analyzing this aspect in adolescents. Thus, due to the potential of PA to develop PF and attention, it was considered important to investigate the students' perception of their PA practice and PF levels, together with the importance of attention in daily tasks or in their academic performance. Therefore, the aim of the present investigation was to analyze and characterize the level of PA, PF and attention in adolescents. It was hypothesized that boys practice more PA, being more active and having a greater predisposition to higher PF than girls; it was also hypothesized that adolescents have a moderate level of attention, with high levels of attention in girls when compared with boys.

Material and Methods

Study design and settings

The study was carried out in a public secondary school in Beja, in two physical education classes, with data collection taking place in January 2020. It was approved by the ethics committee of the Polytechnic Institute of Beja (protocol code No. 04/2019 and date of approval of 5th December 2019) and was following the latest version of the Declaration of Helsinki. Prior to the start of the study, all participants and their parents/guardians were informed about the study procedures. The written informed consent was obtained and signed by parents/guardians of all the participants. In the study an online questionnaire available through Google Forms was provided for the participants. The administration of the questionnaires was supervised by a researcher.

Participants

The sample consisted of 43 adolescents (aged 16.77 ± ± 0.61 years) from one secondary school cluster (Beja, Portugal), who were randomly assigned to the study. The average height of the entire sample was 1.67 ± ± 0.08 m. The inclusion criteria were: i) healthy young; and ii) young people without any type of injury/disorder (physical or mental). The exclusion criteria were: i) adolescents with physical disabilities, chronic or neurological diseases; ii) orthopedic limitation or clinical diagnosis of attention deficit hyperactivity disorders; and iii) regular extra-curricular PA.

Procedures

In this study both PA and PF were assessed by the PA and PF questionnaire, being characterized through questions related to PA and PF. The question concerning the PA levels was answered by providing the number of days PA was practiced in the last 7 days. The function of recoding into different variables was applied, where 0 and 1 day were converted to the value of 1, 2-4 to the value of 2, and 5-7 to the value of 3 respectively, and the value labels were changed to low, moderate, and high (Table 1). The extra-curricular PA practice was related, with answers ranging from "never practiced" to "practice" and "compete". They were also grouped through the function Recode into different variables: "I've never practiced sports" and "I've played sports, but right now I don't practice" assumed the value of 1 and "Yes, I play sports" and "Yes, I play sports and have already been in championships or competitions" assumed the value of 2. The value labels were set to "No" and "Yes" (Table 1).

Different dimensions of PF (fitness assessment, evaluation of cardiorespiratory condition, muscle strength assessment, speed and agility assessment and flexibility assessment) were recoded to the classification between "very bad" to "very good" assuming values from 0 to 4, having been

Table 1. Recoding physical activity

In the last 7-day period how many days was physical activity practiced (original)	In the last 7-day period how many days was physical activity practiced (recoded)
0 days 1 day	low
2 days 3 days 4 days	moderate
5 days 6 days 7 days	high
Practice extra-curricular physical activity (original)	**Practice extra-curricular physical activity (recoded)**
I've never practiced sports I've played sports, but right now I don't practice	No
Yes, I play sports Yes, I play sports and have already been in championships or competitions	Yes

recoded into three different variables. Thus "very bad and bad" received the value of 1 (low), "acceptable" the value of 2 (moderate) and "good and very good" the value of 3 (high). Then the value labels of low, moderate and high were assumed.

In the last recoded variable, for the attention recoding, since the questionnaire used a 4-point Likert scale, the recoding considered the sum ranging from 0 to 27, having been recoded in three different variables, with 0-8 with the value of 1 (low), 9-17 with the value of 2 (moderate) and 18-27 with the value of 3 (high). As before, the value labels of low, moderate and high were assumed.

A Portuguese version [16] of the CAD-S Assessment Scale revised version [5] was administered on the sample, being an evaluation scale approved by the scientific community for Portugal and indicated for the evaluation and diagnosis of attention deficit hyperactivity disorder (ADHD). The scale of attention and concentration consisted of 9 items. The questionnaire used a 4-point Likert Scale, where 0 meant "It's never true" and 3 "It's always true".

Statistical analysis

A cross-sectional descriptive study was performed. Statistical analysis was performed using the IBM SPSS® software, version 24.0 (Armonk, NY, USA). The sample description was made through a frequency analysis of all variables in the study. Standard statistical methods were used to calculate means and standard deviations. To analyze the level of PA, PF and attention in adolescents and verify if there are differences between variables, crosstabs and chi-square test were performed. The normality of the data and the homogeneity were verified. The threshold of statistical significance was set at $p \leq 0.05$.

Results

The sociodemographic characteristics (i.e., gender and age) of the adolescents were recorded (Table 2). The general description of the sample according to the gender frequency analysis showed that there were more boys than girls and that most participants were 17 years old (Table 2).

Table 2. Sociodemographic characterization of the sample (n = 43)

Variable		n	(%)
Gender	female	20	46.5
	male	23	53.5
Age	16	14	32.6
	17	25	58.1
	18	4	9.3

It was verified that most participants practice PA and that boys practice more PA (32.6%). A moderate practice of PA in the last 7 days (60.5%) was recorded where the

Table 3. Characterization of the level of physical activity

Variable		% (n)			$\bar{x} \pm SD$	p
		Female	Male	Total		
Physical activity	low	2.3% (1)	9.3% (4)	11.6% (5)	2.16 ± 0.615	0.169
	moderate	34.9% (15)	25.6% (11)	60.5% (26)		
	high	9.3% (4)	18.6% (8)	27.9% (12)		
	yes	18.6% (8)	32.6% (14)	51.2% (22)	1.51 ± 0.506	0.172
	no	27.9% (12)	20.9% (9)	48.8% (21)		

vast majority are female (34.9%). The response of PA in the last 7 days has a better average than the practice or no practice of PA and there is no significant relationship between PA and gender ($p \leq 0.05$) (Table 3).

A high level of PF in 53.5% of the adolescents was reported, being 39.5% males (Table 4). Considering the self-perception of PF variables, a high perception (46.5%) was revealed for cardiorespiratory fitness, in the case of muscle strength the participants perceived themselves to have moderate strength (60.5%), speed and agility were considered high (46.5%) as well as high flexibility (41.8%) when compared with females. The highest average was reported in variables of PF, speed and agility, where the lowest average was observed in the flexibility variable. No significant relation was found between muscle strength and flexibility. However, PF ($p = 0.005$), cardiorespiratory fitness ($p = 0.003$), speed and agility variables ($p = 0.033$) showed significant differences between the genders (females and males).

Most of the sample (79.1%) demonstrated a high attention rate, where boys reported higher levels of

Table 4. Characterization of the level of physical fitness

Variable		% (n)			$\bar{x} \pm SD$	p
		Female	Male	Total		
Physical fitness	low	**4.7% (2)**	**7.0% (3)**	**11.6% (5)**	2.42 ± 0.698	**0.005***
	moderate	**27.9% (12)**	**7.0% (3)**	**34.9% (15)**		
	high	**14.0% (6)**	**39.5% (17)**	**53.5% (23)**		
Cardiorespiratory fitness	low	**25.6% (11)**	**7.0% (3)**	**32.6% (14)**	2.14 ± 0.889	**0.003***
	moderate	**11.6% (5)**	**9.3% (4)**	**20.9% (9)**		
	high	**9.3% (4)**	**37.2% (16)**	**46.5% (20)**		
Muscle strength	low	7.0% (3)	4.7% (2)	11.6% (5)	2.16 ± 0.615	0.206
	moderate	32.6% (14)	27.9% (12)	60.5% (26)		
	high	7.0% (3)	20.9% (9)	27.9% (12)		
Speed and agility	low	**11.6% (5)**	**0.0% (0)**	**11.6% (5)**	2.35 ± 0.686	**0.033***
	moderate	**18.6% (8)**	**23.3% (10)**	**41.9% (18)**		
	high	**16.3% (7)**	**30.2% (13)**	**46.5% (20)**		
Flexibility	low	9.3% (4)	23.3% (10)	32.6% (14)	2.09 ± 0.868	0.202
	moderate	16.3% (7)	9.3% (4)	25.6% (11)		
	high	20.9% (9)	20.9% (9)	41.8% (18)		

* χ^2 significant values for $p < 0.05$; adjusted residuals $\geq |1.9|$ are considered significant (in bold)

Table 5. Characterization of the level of attention

Variable		% (n)			$\overline{x} \pm$ SD	p
		Female	Male	Total		
Attention	low	0.0% (0)	0.0% (0)	0.0% (0)	1.21 ± 0.412	0.889
	moderate	9.3% (4)	11.6% (5)	20.9% (9)		
	high	37.2% (16)	41.9% (18)	79.1% (34)		

attention than girls. However, no significant differences were observed between attention in the two gender (Table 5).

Discussion

The aim of the study was to analyze and characterize the level of PA, PF and attention in adolescents. The results suggested that the majority of adolescents practice PA (i.e., moderate PA is equivalent to 2-4 days/week). Boys practice more PA (i.e., high PA is equivalent to 5-7 days/week) than girls. The obtained results confirmed our first hypothesis. Previous studies [7, 15, 26] reported that boys showed higher levels of PA than girls, with the levels decreasing drastically during adolescence. On the other hand, Kristensen et al. [15] reported similar PA results for both genders. Moreover, Prieto-Benavides et al. [21] stated that higher levels of PA support higher levels of PF.

In the perception of the adolescents a high level of PF was reported, with boys showing a higher level than girls, who stated a moderate level (27.9%). With regard to PF, in the cardiorespiratory fitness variable a high level was reported mainly in boys. Sasayama and Adachi [26] showed high levels in both genders for cardiorespiratory fitness, which is contradictory to our results, where boys had higher levels than girls. However, Gonçalves and Silva [9] reported findings consistent with our results, indicating that girls had higher prevalence to low levels of cardiorespiratory fitness when compared with boys.

Regarding muscle strength, a majority of the sample (more girls than boys) considered themselves to have a moderate level, although the results also show that there were more boys who considered themselves to have high muscle strength. Sasayama and Adachi [26] reported different results with boys and girls in terms of high levels of muscle strength. In the case of the speed and agility components, high levels were reported by a greater number of boys than girls (46.5%). Interestingly, Sasayama and Adachi [26] showed that both boys and girls had high levels of speed and agility. Finally, in flexibility as the last component of PF, the results were similar to those obtained for the previous variables, and all adolescents showed high levels. Curiously, both girls and boys reported the high level.

Concerning the level of attention the adolescents self-reported high levels, where boys (41.9%) reported better results than girls (37.2%). The second hypothesis of the present study was not verified. Our results are consistent with the results presented by Hillman and Biggan [13], who reported a higher level of PF and a higher level of attention. This fact can be a stimulus for schools to improve levels of PF and promote active lifestyles [19]. So, the higher level of PA leads to a high level of PF, in turn providing high levels of attention [8].

This study has some limitations that should be considered: i) it is a cross-sectional study that does not establish a causal relationship; ii) the sample size does not allow generalizing the results. However, it is also pertinent to report the strengths. The present study highlighted a good perception of the adolescents for their levels of PF and attention, reporting positive effects on their cognitive function. These results of the present study emphasized the importance of PA for the adolescents' health, which provides benefits in physical education classes, but also supports adolescents to obtain better attention capacity, leading to better academic performance. It could be pertinent in future studies to include a large population sample and adolescents with chronic or neurologic diseases to increase the generalizability of the reported results.

Conclusions

The main findings of this study contributed to characterize the levels of PA, PF and attention in adolescents. Those showing that the practice of PA in the adolescents is between 2-4 days a week (moderate PA), indicated an influence of levels of PF and attention, being characterized as high levels. Adolescents reported a good perception of their PA and PF levels, showing positive effects on their cognitive function. Through these results, there is a positive relation between PA and variables such as attention and PF in adolescents. Moreover, the practice of PA daily at school and in extracurricular contexts seems to be fundamental to obtain high levels of PF and attention, contributing to better academic performance and life quality.

Therefore, the current findings can be helpful for teachers and sport sciences professionals to innovate in physical education classes and to optimize exercise training programs, guaranteeing the motivation and practice for youth in those contexts.

Conflict of Interest

The authors declare no conflict of interest.

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In Italy compatibility between qualifying training objectives of degree courses in sport sciences and exercise and the kinesiologist profile

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Abstract
Introduction. In Italy the 2021 sport reform established the new profession of kinesiologist, granted only to graduates of three-degree courses in sport sciences. The curricula of these degree courses, in addition to complying with training objectives to become a physical education (PE) teacher, must also be compatible with the profile of a kinesiologist. Aim of Study. The aims were two: 1) measuring the European credits transfer system (ECTS) of three training domains: sport and physical activity, biomedicine and psychopedagogy, to establish their consistency with kinesiology; 2) verifying the relationship between ECTS of the three training domains in all degree courses. Material and Methods. The sample was the whole population of degree courses in sport sciences in Italy. Central tendency and dispersion indices were estimated to analyze the ECTS score to achieve the first aim, while the Chi Square test was performed to achieve the second one. Results. The lower number of ECTS credits for sport and physical activity made the formation not congruent respecting the qualifying training objectives and the fluctuation of mean, median and mode values as well as standard deviation, made the formation even less compliant with respect to the three professional profiles of kinesiologist. Three significant relationships were identified among the ECTS of the three domains in two-degree courses, which therefore implied that they were probably part of the formation of the system. Conclusions. The study did not present limitations of sampling because the entire population was analyzed and the originality was high, because no similar study could be found in the literature.

KEYWORDS: sports sciences, physical education, health, well-being, reform.

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Introduction

On February 26, 2021, the sports reform was enacted, marking a turning point for sport science [8]. In this reform, the law proposed on August 8, 2019 no. 86 was approved, starting a set of very important procedures, including the recognition of the profession of a kinesiologist at the legislative level in its three forms. In fact, the professions of the basic kinesiologist, the kinesiologist of preventive and adapted physical activities, sports kinesiologist and sports manager have been established [9]. In application of this reform, a register will be established, which main advantage is connected with the qualification for the profession, the exercise of which is exclusive. Before this legislation, the kinesiologist profession did not exist and the related professional activities were also exercised by those, who did not possess the specific qualification, required by the new legislation. Recognition of the profession will also imply advantages from a contractual point of view; contracts will also have to be regulated with the norms inherent to the national collective work contract system. In order to exercise the professional activity of basic kinesiologist, it is necessary to have a three-year degree in Sport Sciences and Physical Activity (code L-22). The article no. 41 point 1 of the decree states that the exercise of the professional activity of basic kinesiologist has as its object: "the conduct, management and assessment of individual and group physical activities with a compensatory, educational, recreational and sports character, aimed to maintain and recover the best condition of physical well-being in various age groups, through the promotion of active lifestyles" [8]. Consequently, those who have acquired this degree, will have a specialization in personal training and non-competitive athletic training. For the professional activity of a kinesiologist of preventive and adapted physical activities, it is necessary to have a Master's degree in Science and Techniques of Preventive and Adapted Physical Activities (code LM-67). The article no. 41 point 2 of the decree states that the exercise of the professional activity of a kinesiologist of preventive and adapted physical activities has as its object: "the conduct, management and assessment of individual and group physical activities with a compensatory, educational, recreational and sports character, aimed to maintain and recover the best conditions of physical well-being in various age groups, through the promotion of active lifestyles" [8]. Particular interest deserves the profession of a sports kinesiologist. According to article no. 41 point 4 of the decree, the exercise of the professional activity of a sports kinesiologist has as its object: "the design, coordination and technical direction of athletic training activities in the competitive field up to the highest levels of competition for associations and sports clubs, sports promotion bodies, institutions and specialized centers, physical and technical preparation, finalized to individual and team competitions" [8]. Consequently, those who have acquired this degree will have a very specific specialization, in what concerns agonism. Finally, the professional activity of sports manager requires a master's degree in organization and management of services for sports and physical activities (code LM-47). The article no. 41 point 5 of the decree states that the professional activity of sports manager has as its object: "the planning and management of sports facilities; the management of public and private facilities where physical activities are performed, including recreational activities; the organization, as an expert and consultant, of sports events, including recreational activities" [8]. For these legal requirements, there must be the necessary consistency in the choice of training activities for each individual degree (three-year and master's) and, above all, the congruence (quantity of these training activities in terms of units of measurement defined at the international level by the Bologna ECTS process) in those areas peculiar to the three new professional profiles.

Today, the term kinesiology is only a question of academic and scientific consensus. It should be accepted as a global and universal term for the science and profession in question. However, such agreements are often more political than truly scientific in nature [2]. The kinesiologist is a professional figure, employed in the field of human movement, with the aim of promoting personal well-being. To help educate more experienced coaches in participation and performance, a number of governing bodies have instituted coach-mentoring systems [12]. If mentors are to be effective in training experienced coaches, we argue accordingly that a focus on personal epistemology is necessary. Thus, the goal is twofold. Firstly, it is to promote activity theory as a credible and alternative lens for viewing and researching sport coaching. Secondly, it is to position this statement within the larger debate about coaching epistemology [11]. The recognition of this event is also important to preserve people's health and well-being, through the adoption of correct lifestyles [13]. In Italy, physical activity was not a regulated professional field, like physiotherapists, for whom the law prescribed only academic degrees to carry out professional activities.

Therefore, the importance of the formation of the kinesiologist, able to operate in the field of active human movement, and aimed to the prevention, achievement and improvement of the psychophysical well-being, emerged. When considering the need to investigate this topic, we believed it was important to assess the quality of the research carried out; in particular, to verify the consistency between the theoretical referential adopted and the methodological choice, involving the epistemological line of thought as well as the research techniques selected by the authors of that research [1, 7]. Starting from the legislative change and the specificity of the kinesiologist role, it was necessary to analyze the training domains of L22, LM67 and LM68 degree courses, to verify the most qualified profile for the profession of physical education (PE) and sports science teacher in school [4, 5]. The problem was that each University's degree course had a different distribution of ECTS in the three training domains, i.e., sport and physical activity, biomedicine and psychopedagogy. Sport and physical activity domain unified the academic disciplines on sport and physical activities; the psychopedagogical domain comprised the academic disciplines of pedagogy, didactics and psychology; finally, the biomedical one with the academic disciplines on the biological, medical and clinical aspect of locomotion and sport [3]. The curricula of these degree courses, L22, LM67 and LM68, in addition to being congruent to training objectives to become PE teacher, thanks to the addition training in pedagogical field, must also be congruent with the profile of kinesiologist.

Aim of Study

The aims were two: 1) measuring the amount of European credits transfer system (ECTS) of three main training domain: sport and physical activity, biomedicine and psychopedagogy, to establish their congruence to kinesiologist; 2) verifying the relationship among ECTS of the three training domains in all degree courses. The usefulness of the first objective was to describe the state of the art of the distribution of ECTS, related to three training domain of degree courses in sport science. The second aim was useful to verify the achievement of the training objectives of the kinesiologist and whether they were part of a systemic action of all degree courses of PE in Italy, in order to obtain the full involvement of the scientific community at the highest level, as it was desirable for the profession of PE teacher in primary school [6], in view of the compulsory two hours of PE in primary school by the teacher with a master's degree in sport science [10].

Material and Methods

Design and participants

The sample was the whole population of degree courses in sport sciences in Italy: no. 41 of L22, no. 31 of LM67 and no. 20 of LM68. The survey was documental, using the Universitaly portal, a platform that allows having all the data of the degree and higher education courses in Italy, including the ECTS for each degree course of all the Universities. The Universities that offered these three-degree courses were collected, and their ECTS, relating to the three training domains, were extrapolated.

Statistical analysis

Central tendency and dispersion indices were estimated to analyze the number of ECTS of the three training domains. Chi Square was performed to test the relationship among ECTS of the three training domains in all degree courses. This non-parametric test responded better to the demands formulated in the objective because it was able to identify possible significant relationships. Statistical significance was set at $P < 0.05$. Data were analyzed using SPSS (IBM SPSS Statistics for Windows, Version 25.0, Armonk, NY).

Results

The central tendency indices (mean, median, and mode) and dispersion indices (standard deviation) of ECTS in L22, subdivided by training domains, are shown in Table 1.

Table 1. Central tendency and dispersion indices of ECTS in L22 courses subdivided by training domains/areas

L22 – no. 41 Universities	Domain		
	Sport and physical activity	Biomedical	Psychopedagogical
Tot ECTS	2132	2552	855
Mean	25	19	10
Mode	24	9	10
Median	24	17	10
Standard deviation	10.2	12.6	5.6

The indices of central tendency (mean, median, mode) and the indices of dispersion (standard deviation) of ECTS in LM67, subdivided by training domains, are shown in Table 2.

Table 2. Central tendency and dispersion indices of ECTS in LM67 courses subdivided by training domains/areas

LM67 – no. 31 Universities	Domain		
	Sport and physical activity	Biomedical	Psychopedagogical
Tot ECTS	884	1069	315
Mean	28	34	10
Mode	20	18	7
Median	28	35	8
Stardard deviation	7.2	9.1	4.3

The indices of central tendency (mean, median, mode) and the indices of dispersion (standard deviation) of ECTS in LM68, subdivided by training domains, are shown in Table 3.

Table 3. Central tendency and dispersion indices of ECTS in LM68 courses subdivided by training domains/areas

LM68 – no. 20 Universities	Domain		
	Sport and physical activity	Biomedical	Psychopedagogical
Tot ECTS	718	539	172
Mean	35	26	8
Mode	28	15	6
Median	36	26	7
Standard deviation	6.3	9.1	4.7

From Chi Square analysis, a significant relationship was found between: ECTS of sport and physical activity and biomedical domain in L22 (X^2 = 1376.76; p = 0.00); ECTS of biomedical and psychopedagogical domain in L22 (X^2 = 706.76; p = 0.01); ECTS of sport and physical activity and biomedical domain in LM68 (X^2 = 186.66; p = 0.03). A detailed description is shown in Table 4.

Discussion

The ECTS of sport and physical activity, biomedical and psychopedagogical domains were 2132, 2552 and 855 in L22; 844, 1096 and 315 in LM67; 718, 539 and 172 in LM68 degree courses with mean, mode and median, as well as standard deviation different. The indices of central tendency and dispersion of ECTS related to the three domains, so inhomogeneous and dispersive, did not permit the identification of common matrix of the three-degree courses. This is because, by law, the scientific profile of the basic kinesiologist, the sports kinesiologist and the kinesiologist of preventive and adapted motor activities is defined. Therefore, it could be said that there was no systemic action at the level of the degree courses.

Regarding the adequacy of training credits relating to the profession of kinesiologist and therefore strictly to the sport field, only LM68 class had this characterization. This situation emerged from a comparison of the qualifying educational objectives of the three-degree programs and the respective objectives of the professional figures of the basic kinesiologist, the sports kinesiologist, and the

Table 4. Chi Square analysis between ECTS of all domains in all degree courses

Variable 1	Variable 2	Chi Square (X^2)	Sign.
ECTS in sport and physical activity domain (L22)	ECTS in biomedical domain (L22)	1376.76	0.00
	ECTS in psychopedagogical domain (L22)	464.04	0.84
	ECTS in sport and physical activity domain (LM67)	208.59	0.71
	ECTS in biomedical domain (LM67)	395.25	0.21
	ECTS in psychopedagogical domain (LM67)	176.14	0.35
	ECTS in sport and physical activity domain (LM68)	175.833	0.11
	ECTS in biomedical domain (LM68)	201.66	0.37
	ECTS in psychopedagogical domain (LM68)	119.72	0.29
ECTS in biomedical domain (L22)	ECTS in psychopedagogical domain (L22)	706.76	0.01
	ECTS in sport and physical activity domain (LM67)	289.85	0.42
	ECTS inn biomedical domain (LM67)	496.00	0.34
	ECTS in psychopedagogical domain (LM67)	209.80	0.67
	ECTS in sport and physical activity domain (LM68)	187.50	0.47
	ECTS in biomedical domain (LM68)	245.00	0.36
	ECTS in psychopedagogical domain (LM68)	144.16	0.30
ECTS in psychopedagogical domain (L22)	ECTS in sport and physical activity domain (LM67)	131.33	0.17
	ECTS in biomedical domain (LM67)	207.35	0.31
	ECTS in psychopedagogical domain (LM67)	102.04	0.18

ECTS in psychopedagogical domain (L22)	ECTS in sport and physical activity domain (LM68)	79.72	0.72
	ECTS in biomedical domain (LM68)	118.33	0.32
	ECTS in psychopedagogical domain (LM68)	56.29	0.72
ECTS in sport and physical activity domain (LM67)	ECTS in biomedical domain (LM67)	311.89	0.14
	ECTS in psychopedagogical domain (LM67)	148.98	0.12
	ECTS in sport and physical activity domain (LM68)	111.66	0.71
	ECTS in biomedical domain (LM68)	160.00	0.35
	ECTS in psychopedagogical domain (LM68)	89.16	0.44
ECTS in biomedical domain (LM67)	ECTS in psychopedagogical domain (LM67)	216.26	0.55
	ECTS in sport and physical activity domain (LM68)	207.50	0.30
	ECTS in biomedical domain (LM68)	260.00	0.35
	ECTS in psychopedagogical domain (LM68)	145.00	0.46
ECTS in psychopedagogical domain (LM67)	ECTS in sport and physical activity domain (LM68)	93.50	0.09
	ECTS in biomedical domain (LM68)	107.66	0.35
	ECTS in psychopedagogical domain (LM68)	48.16	0.76
ECTS in sport and physical activity domain (LM68)	ECTS in biomedical domain (LM68)	186.66	0.03
	ECTS in psychopedagogical domain (LM68)	106.25	0.09
ECTS in biomedical domain (LM68)	ECTS in psychopedagogical domain (LM68)	127.50	0.15

preventive and adapted physical activity kinesiologist. There must be consistency between what is defined by law and the qualifying objectives of these three-degree programs. Today, due to the specific provision of the law, "By decree of the President of the Council of Ministers or the political authority delegated by him on sports, in agreement with the Minister of University and Research, are dictated the implementing provisions concerning the training path and the identification of the professional profile of the basic kinesiologist, the sports kinesiologist and the sports manager" [8] it is no longer appropriate to verify whether there is consistency and congruence with the educational objectives of the current regulatory provisions on the classes of study L22, LM67 and LM68.

In addition, LM67 had a prevalence of ECTS in the biomedical domain, compared to the sport and physical activity and psychopedagogical, therefore, was closer to the health professions and not the educational ones. It is necessary to consider that there already exist the three-year degree and the master's degree in physiotherapy, which have other qualifying educational objectives with respect to the three-year and master's degree courses in exercise science. In fact, the graduates in the class of degrees in health professions, pursuant to Article 6, paragraph 3 of legislative decree 30/12/1992 no. 502 and subsequent amendments and additions are indicated as "the only ones appropriate to carry out activities directed to prevention, care, rehabilitation and functional evaluation procedures in the implementation of the regulations concerning the identification of figure and related professional profiles" [8] defined by decree of the Ministry of Health. This comparison shows that the kinesiologist should not have a health profile but an educational profile. So, there should be more credits of psychopedagogical and sport-motor than biomedical ones.

Also, in L22, the prevailing domain was the biomedical one. According to D'Elia's study [4], in Italy, regarding the three-year degree course in L22, most of ECTS were focused on the biomedical area, followed by sport and physical activity and psychopedagogical. Bachelor's degree courses were mainly designed to develop biological, biomedical and clinical competencies rather than competencies in design, management, planning and evaluation of sport and physical activity.

In LM68, the prevalence of the sport and physical activity domain emerged, so it seemed to be the most appropriate degree course respecting the professional figure of the kinesiologist. Finally, the profiles of PE teacher and kinesiologist were unbalanced regarding the psychopedagogical domain because in LM68 there were 172 ECTS, while in LM67 there were 315 ECTS. In brief, the lower number of ECTS of sport and physical activity made the formation not congruent respecting the qualifying training objectives and the oscillation of mean, median and mode values as well as standard deviation, made the formation even less congruent with respect to the three professional profiles of kinesiologist.

Three significant relationships were identified among the ECTS of the three domains in two-degree courses, which therefore implied that they were part of the formation of the system. The first concerned the relationship between the ECTS of the sport and physical activity domain and those of the biomedical domain in L22 degree course. The second one concerned the relationship between the ECTS of the biomedical domain and those of the psychopedagogical one in L22 degree course. The last one concerned the relationship between the ECTS of the sport and physical activity domain and those of the biomedical domain in LM68 degree course. This implied a connection between the ECTS of sport and physical activity biomedical domain both in L22 and LM68, and between the ECTS of the biomedical and psychopedagogical domain in L22, which were probably part of the formation of the system, unlike the others which, being independent of each other, were not part of it. The absence of significant relationships between the ECTS of the three training domains in LM67 was a clear sign that it needs a revision at the level of the distribution of ECTS in the three domains, in order to make the formation more appropriate for the profession of kinesiologist. It should balance an increase in the tabular minima of the three domains in order to equalize the distribution over the population of data, to make it part of a systemic action.

The study did not present limitations of sampling because the entire population was analyzed and the originality was high because no similar study could be found in the literature. This study provides useful elements for the fulfillment of the specific legal requirement of article 41 that: “By decree of the President of the Council of Ministers or the political authority delegated by him on sports, in agreement with the Minister of University and Research, the implementing provisions are dictated concerning the training program and the identification of the professional profile of the basic kinesiologist, the sports kinesiologist and the sports manager” [8].

Conclusions

In conclusion the formation of degree course that most reflected the kinesiologist role was proposed by LM68 for the greater presence of ECTS related to sport and physical activity domain compared to the other two. Particular attention should be given to the other two-degree programs, L22 and LM67, because the prevalence of ECTS were both in the biomedical domain, and poorly reconciled with the profession of kinesiologist. In particular, LM67 was particularly unbalanced on the biomedical domain, more appropriate for the physiotherapist profile. An attempt should be made to homogenize the degree programs, also trying to take into account the characteristics and formation of the professional figure of kinesiologist. Finally, it was found a connection between the ECTS of sport and physical activity biomedical domain both in L22 and LM68, and between the ECTS of the biomedical and psychopedagogical domain in L22, which were probably part of the formation of the system, unlike the others which, being independent of each other, were not part of it.

Conflict of Interest

The authors declare no conflict of interest.

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Acral Coactivation Therapy method in terms of improving the musculoskeletal system in pupils in physical and sport education

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Abstract
Introduction. **The quality of the musculoskeletal system in children is important in terms of primary prevention of postural health in adulthood.** Aim of Study. **The pilot study focused on the implementation of the Acral Coactivation Therapy (ACT) method in the teaching of physical and sport education in terms of improving the postural health of pupils with an emphasis on the muscular system and overall posture as a manifestation of its functionality.** Material and Methods. **The sample consisted of n = 16 pupils (14.21 ± 0.71 years; 54.25 ± 4.25 kg; 161.09 ± 4.56 cm) attending primary school. In terms of ensuring longevity and cross-sectionality in the surveys, available and standardized methods for physical education practice were applied.** Results. **The obtained results point to the followeing findings. While in control period V (1-2) we did not notice significant changes (p > 0.05) in the area of body posture and muscular system, in experimental period V (3-4), after applying the ACT method, we noticed overall significant (Wtest p < 0.05, r = 0.69) changes in the overall body posture of pupils with a high effect size, as well as in the muscular system (p < 0.05). In terms of difference and comparison of changes between control V (1-2) and experimental V (3-4) period ES (n = 16) in body posture and muscle groups, we noticed significant differences in favor of experimental period V (3-4), (Mann–Whitney test p < 0.05).** Conclusions. **These findings point to the importance of the application of targeted exercises in relation to the pupil's postural health, implemented in physical and sport education. At the same time, there is a significant need to improve the content of the subject physical education and sport in terms of diversification and towards the health of pupils.**

KEYWORDS: ACT method, physical education and sport, musculoskeletal system, pupils.

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Introduction

In the modern world of computer and electronics development, from the youngest years children and teenagers choose sedentary leisure time activities (sitting in front of a computer, TV). Passive mobility becomes the cause of muscular disbalance, which may be a risk factor for abnormalities in body posture [9, 22]. The 21st century is marked on the one hand by modern digitalization and on the other hand by the elimination of physical activity in the lives of children and young people, which results in incorrect body posture and malfunctioning of the musculoskeletal system. Children often experience pain during this period and there is an increase in changes and disorders of a functional and structural character in the musculoskeletal system [3, 7, 11, 18, 30]. Low levels of physical activity undertaken by children and adolescents have an impact on the posturogenesis process, that is the development of the osteoarticular system, and thus future development

of the body. Postural defects in both children and adolescents are an important public health problem and a challenge for the primary care and education system. Some studies point to the fact that the problem of postural defects applies to 20-40% of children and adolescents, but there are also publications giving much higher values [27].
Spinal deformity as well as defects of feet and knees are the most common health problem of children and youth, even more common than allergies, eye disorders of refraction and accommodation, obesity, or other diseases. According to various sources, 50-60% of pupils suffer from postural defects. These problems develop during the so-called growth spurts (ages 6-7 and 12-16) when the development of the muscular system does not keep up with the fast growth of bones [15].
Postural defects may result in serious diseases in adult life, such as e.g., cardiorespiratory disorders, physical performance impairment, back pains, and gynecological issues in women. Spinal stability means the ability to fix the spinal configuration, which is given by the shape of the vertebrae and the curvature of the spine, and subsequently to maintain this basic position within the physiological range of motion. We recognize the static, i.e. resting, and dynamic stability of the spine, which occurs during movement. In terms of the involvement of muscle chains, we speak of the vertical stabilization in the static and the spiral stabilization in the dynamic position. With the right synergy of muscle chains, we can observe the application of movement patterns of the spine in its stabilization. The failure of the stabilization function is manifested by a violation of the alternation of vertical and spiral stabilization, with static stabilization still prevailing in the dynamics [28].
The deep stabilization system plays an important role in the musculoskeletal system. The deep stabilization system is formed by muscles, which are embedded in deep layers of the muscular corset, more tightly around the spine, in the belly and the underbelly. These muscles stabilize the spine, thus markedly influencing the body posture and forming a fixed support for the movement of the extremities. Muscles of the deep stabilization system participate in each targeted movement, activate themselves at any static loading. For their activity it is not strength that is important, but the quality of their engagement, which is automatic, without conscious influence. Malfunctions of the deep stabilization system are the substance of malfunctions of the motion system, which originate because of natural movement. Each malfunction in internal forces of the deep stabilization system leads to problems, which are reflected in movement activity. Therefore, targeted influencing of the stabilization function of the spine is the foundation for good quality of movement performance [25].
At present, active health and active rest in the exercise regime of the school population are increasingly being put into the foreground, as they contribute to the quality of postural health, the musculoskeletal system, as one of the factors of health-oriented fitness with a sense of posture and movement stereotypes, as stated by Bendíková [6]. Prevention through physical activity and healthy lifestyles, based on strong medical evidence, is the most cost effective and sustainable way to tackle these problems and to support positive social development [12].
Regular and quality physical education and sport can help children and adolescents achieve the recommended amount of daily vigorous-or moderate-intensity physical activity and improve fitness and body posture as well [4]. In this context, it is important to say that prophylaxis of bad posture in children requires knowledge concerning prevention itself and the role of correct body posture, as well as motivation, abilities, and prophylaxis implementation. It is also important to undergo screening and prophylactic medical examination for early diagnosis. Schools should provide conditions fostering healthy development, which also covers preventive healthcare.

Aim of Study

The pilot study focused on the implementation of the Acral Coactivation Therapy (ACT) method in the teaching of physical and sport education to improve the postural health of pupils with an emphasis on the muscular system and overall posture as a manifestation of its functionality.

Material and Methods

Participants

The sample consisted of pupils of pubescent age (14.21 ± ± 0.71 years) in the total number n = 16, who attended primary school. The experimental group consisted of pupils with an average body height of 161.09 ± 4.56 cm, body weight of 54.25 ± 4.25 kg and a BMI of 20.53 ± ± 2.85. The pupils were included in the pilot research based on established research conditions (participation in the research with the consent of legal representatives, problems in the musculoskeletal system, regularity of participation in physical education classes and sport activities. The primary characteristics of the experimental sample (ES) are presented in Table 1.

Table 1. Characteristics of the sample of pupils

Sample/factors	$ES_{n=16}$		
Measurements/ values	Body height (cm)	Body weight (kg)	BMI (kg/m^2)
x	161.09	52.21	20.53
s	4.56	4.25	2.85
min.	152.12	45.32	18.32
max.	164.55	54.86	22.21
$R_{max–min}$	12.43	9.54	3.89

Note: ES – experimental sample, (n) – number, (x) – average, (s) – standard deviation, (min.) – minimal value, (max.) – maximal value, R($_{max–min)}$ – range of variation

Procedure and measurements

In terms of ensuring longevity and cross-sectionality in the surveys, we applied a standardized aspect method of body posture assessment for school practice to determine the condition of the musculoskeletal system (Thomas and Klein as modified by Mayerom). Body posture is evaluated in four levels: 1. Correct (5 points), 2. Good (6 to 10 points), 3. Bad (11 to 15 points), 4. Incorrect (16 to 20 points). Each degree of body posture has five characters: 1. Posture of the head and neck, 2. Shape of the chest, 3. Shape of the abdomen and pelvic inclination, 4. Total spine curvature, 5. Height of the shoulders and position of the shoulder blades. Each character is evaluated by mark 1-4. Subsequently, we applied the method of evaluating the muscular system. We evaluated the group of muscles with a tendency to shorten: m. trapezius, pars superior, m. levator scapulae, m. pectoralis major, m. iliopsoas, m. rectus femoris, m. tensor fasciae latae, hip joint adductors, knee joint flexors, m. quadratus lumbrorum, m. erector spinae, and triceps surae. Subsequently, we evaluated a group of muscles with a tendency to weaken: deep neck flexors, mm. abdominis, lower scapular fixators, hip joint extensors, hip joint abductors, and shoulder abductors [5].

The said exercise program was based on applied targeted health-oriented exercises, which were based on the ACT method, which has copyright and a protection license, authored by Palaščáková Špringrová [25]. The ACT method is based on the application of a set of support exercises, which lead to muscle coactivation in order to positively affect the stabilization and straightening of the axial organ, spine, as well as the activation of the internal stabilization system. From a neurophysiological point of view, the basis of the acral coactivation therapeutic method is the use of the positions of human motor ontogenesis and the principles of motor learning. It follows from the above that the basis of the method is to correct incorrect movement stereotypes through motor learning and to achieve its re-acquisition. The exercises were based on the current functional status of the observed factors of the musculoskeletal system ($V_{1–2}$, $V_{3–4}$) of ES pupils [25].

ES pupils in the first stage of the research (control period) $V_{(1–2)\ 2022}$ completed the entrance $V_{(1)\ 2022}$ evaluations of the monitored factors and subsequently for 8 weeks 2 times/week they took part the physical education and sport lessons in compliance with the content (TC) of the school curriculum. Subsequently, they completed the final $V_{(2)\ 2022}$ evaluation, on the basis of which we incorporated exercises of ACT methods with a health focus into the content of teaching physical education and sport. ES performed ACT exercises (experimental period) for 8 weeks $V_{(3–4)\ 2022}$ 2 times/ week, 15 minutes during the preparatory and final part of the physical education and sport lessons. The realized experiment was pedagogical, one-group, non-parallel and multifactor (called quasi-experiment). The experimental factor was a set of ACT exercises, thanks to which we created a consequential dependent experimental factor, which formed the functional state of the musculoskeletal system in pupils ($V_{1–2}$, $V_{3–4}$). This research was conducted during the Covid-19 pandemic.

Statistical analyses

In terms of data processing, we applied descriptive statistics procedures – arithmetic mean (x), standard deviation (s), percentage frequency analysis (%), frequency (n) and range of variation ($R_{max–min}$). We assessed the practical and material significance using the effect size (r). Furthermore, we processed the obtained qualitative-quantitative data using theoretical methods of induction, deduction, logical analysis, and synthesis. To determine the statistical significance of the difference between the input and output evaluations for the observed indicators in the sample, we used the Wilcoxon test $W_{(test)}$ ($p < 0.05$) and to compare the difference between $V_{(1–2)}$ and $V_{(3–4)}$ we applied the Mann–Whitney test ($p < 0.05$).

Results

In the first phase of the experimental period $V_{(1–2)}$ (the control phase) we observed no significant changes in the total body posture in the ES between $V_{1–2}$ (W_{test} = = 0.598, $p > 0.05$), while the difference between the input (V_1 12.31 ± 1.63) and the output (V_2 12.94 ± 1.60) evaluation was at a level of 0.63 ± 0.03.

During the second phase of the experimental period $V_{(3–4)}$, we applied ACT exercises within physical education and sport lessons with a focus on the overall complex body posture of pupils. Comparing the quality of ES body posture during $V_{(3–4)}$, we found that the average difference between the input (V_3 11.69 ± ± 1.82) and output (V_4 6.23 ± 1.35) scores was 5.46 ± ± 0.47, indicating an overall improving body posture in pupils after the application of our ACT exercises. In ES, we noticed significant changes in body posture between input V_3 and output V_4 (W_{test} = 0.002, $p < 0.05$, r = 60). Between periods $V_{(1–2)}$ and $V_{(3–4)}$ ES, we noticed significant changes (Mann–Whitney test = 0.00004, $p < 0.05$) in the monitoring of total body posture (Table 2).

In the muscular system, as well as in total body posture, in the control period $V_{(1–2)}$ in the $ES_{(n = 16)}$, no significant differences were recorded in monitored muscle groups of postural (W_{test} $p > 0.05$) and phasic character (W_{test} $p > 0.05$). During the control period $V_{(1–2)}$, we noticed a muscle imbalance in the ES, which also manifested itself in III quality level in overall body posture. The postural muscle groups at the greatest risk of disorders included m. trapezius pars superior (1.46 ±

Table 2. Total body posture in pupils ES

Sample	$ES_{(n = 16)}$ $V_{(1–2)}$			$ES_{(n = 16)}$ $V_{(3–4)}$		
Factors/measurements	V_1	V_2	R_1	V_3	V_4	R_2
x	12.31	12.94	0.63	11.69	6.23	5.46
s	1.63	1.60	0.03	1.82	1.35	0.47
min.	8	7	-1	5	2	3
max.	15	14	1	14	8	6
$R_{max–min}$	7	5	2	9	6	3
Wilcoxon test		0.598, $p > 0.05$			0.002, $p < 0.05$	
Mann–Whitney test			$p < 0.05$			

Note: ES – experimental sample, n – number, x – average, s – standard deviation, min. – minimal value, max. – maximal value, $R_{max–min}$ – range of variation, V_1, V_3 – input, V_2, V_4 – output, R_1 – difference $V_{(1–2)}$, R_2 – difference $V_{(3–4)}$

Table 3. Evaluation of postural muscle groups in pupils

Sample/research phase	$ES_{(n = 16)}$ $V_{(1–2)}$		$ES_{(n = 16)}$ $V_{(3–4)}$	
Muscle groups	R_1x ± s	W_{test}	R_2x ± s	W_{test}
1. m. trapezius, pars superior	0.09 ± 0.05	$p > 0.05$	0.92 ± 0.11	$p < 0.05$
2. m. levator scapulae	0.04 ± 0.02	$p > 0.05$	0.72 ± 0.17	$p < 0.05$
3. m. pectoralis major	0.02 ± 0.02	$p > 0.05$	0.79 ± 0. 34	$p < 0.05$
4. m. iliopsoas	0.05 ± 0.03	$p > 0.05$	0.78 ± 0.27	$p < 0.05$
5. m. rectus femoris	0.03 ± 0.01	$p > 0.05$	0.65 ± 0.22	$p < 0.05$
6. m. tensor fasciae latae	0.00 ± 0.00	$p > 0.05$	0.36 ± 0.25	$p < 0.05$
7. m. hip joint adductors	0.00 ± 0.00	$p > 0.05$	0.29 ± 0.22	$p < 0.05$
8. m. knee joint flexors	0.07 ± 0.06	$p > 0.05$	0.64 ± 0.28	$p < 0.05$
9. m. quadratus lumbrorum	0.02 ± 0.02	$p > 0.05$	0.50 ± 0.23	$p < 0.05$
10. m. erector spinae	0.07 ± 0.03	$p > 0.05$	0.43 ± 0.29	$p < 0.05$
11. m. triceps surae	0.08 ± 0.04	$p > 0.05$	0.65 ± 0.22	$p < 0.05$

Note: ES – experimental sample, n – number, x – average, s – standard deviation, W_{test} – Wilcoxon test, $V_{(1–2)}$ – control phase, $V_{(3-4)}$ – experimental phase, R_1 – difference $V_{(1–2)}$, R_2 – difference $V_{(3–4)}$

Table 4. Evaluation of phasic muscle groups in pupils

Sample/research phase	$ES_{(n = 16)}\ V_{(1–2)}$		$ES_{(n = 16)}\ V_{(3–4)}$	
Muscle groups	$R_1 x \pm s$	W_{test}	$R_2 x \pm s$	W_{test}
1. deep neck flexors	0.00 ± 0.00	p > 0.05	0.62 ± 0.19	p < 0.051
2. mm. abdominis	0.19 ± 0.03	p > 0.05	0.99 ± 0.19	p < 0.05
3. mm. lower scapular fixators	0.8 ± 0.03	p > 0.05	0.40 ± 0.19	p < 0.05
4. hip joint extensors	0.03 ± 0.03	p > 0.05	0.85 ± 0.19	p < 0.05
5. hip joint abductors	0.05 ± 0.02	p > 0.05	0.41 ± 0.19	p < 0.05
6. shoulder abductors	0.6 ± 0.03	p > 0.05	0.87 ± 0.21	p < 0.05

Note: ES – experimental sample, n – number, x – average, s – standard deviation, W_{test} – Wilcoxon test, $V_{(1–2)}$ – control phase, $V_{(3–4)}$ – experimental phase, R_1 – difference $V_{(1–2)}$, R_2 – difference $V_{(3–4)}$

± 0.27), m. pectoralis major (1.40 ± 0.22), and hip flexors (1.39 ± 0.24). The abdominal area (1.48 ± 0.09), shoulder abductors (1.44 ± 0.07), and lumbar extensors (1.41 ± 0.09) dominated in the group of phasic muscle groups. No changes were noticed in the input assessments V_3 in the $ES_{(n = 16)}$.

We noticed significant changes after the experimental period $V_{(3–4)}$ by applying the ACT method, which was significantly (W_{test} $p < 0.05$) manifested in individual muscle groups (Tables 3, 4).

The functional quality of muscle groups and the correct execution of movement stereotypes manifested itself after the experimental period in controlled body posture, which we evaluate positively in terms of education promoting the postural health of pupils. The development in $ES_{(n = 16)}$ occurred in $V_{(4)}$, by the improvement from III quality grade to II quality of overall body posture.

In terms of differences and comparison of changes between the control $V_{(1–2)}$ and experimental $V_{(3–4)}$ periods (n = 16) in muscle groups, we noticed significant differences in favour of the experimental period $V_{(3–4)}$, which was also confirmed by the results of the Mann–Whitney test ($p < 0.05$).

This fact shows that even a controlled and conscious stabilization of body posture resulted in the functionality and improvement of the musculoskeletal system. This is because body posture is one of the basic postural stereotypes within the movement patterns, from which others derive and are related to.

Discussion

Diseases of civilization (also called lifestyle diseases) are non-communicable, usually have a long duration, progress slowly, and are usually the result of genetics, the environment, or a bad lifestyle. Diseases of the musculoskeletal system are also among the diseases of civilization. Body posture is defined as the ideal position adopted by human beings for their daily activities through their body structures and function in order to have better biomechanical efficiency with lesser energy expenditure. However, this is not always possible, as habits are often adopted which may disregard this pattern and lead to postural changes [1, 16].

Ningthoujam [23] considered "posture" as a product of human behaviour, emphasizing that factors affecting a wrong posture are features of daily behaviour. According to that author "posture" reflects the well-being of the individual, reflects the person's activity and somehow relevant personality.

Correct posture, which represents the organization and balance of the body system, requires a position of alignment and support of the musculoskeletal structures between the various segments, which involves the adoption of a healthy lifestyle. According to Graup et al. [13], incorrect posture habits and remaining in a sitting position for long periods lead to an imbalance of the musculoskeletal system and compromise the body structure. These factors are recurrent in the school population, arising from the activity itself and the absence of mechanisms to encourage the adoption of the correct posture. Thus, the sitting posture leads to an overload on the ischial tuberosity, due to the body weight leaning forward and reducing the myofascial flexibility, while the upright torso supports the constant action of the abdominal and back muscles. Moreover, shortened ischia and ileus muscles result in painful symptoms, causing lordosis of the lumbar region, which increases the burden on the spine and the discs.

The abdominal muscles are an important muscle group which, in the event of weakness, does not fulfil its function of supporting the spine or stem. The resulting muscle imbalance affects the pelvic tilt, which can lead to an increase in lumbar lordosis and subsequent pain in the lumbar region of the spine. Correct posture is a body system that provides proper conditions for all body functions, and at the same time, enables active human behaviour towards the environment. This behaviour requires a certain state of alertness, which is associated with greater metabolism and significant energy expenditure. This is true when measuring muscle EMG for correct and improper postures. In a correct posture, EMG shows more intensive muscle work [17, 20].

Thus, the economic importance of correct posture lies not in the fact that the body is released from effort, but in the fact that it is not exposed to excessive expenditure, which occurs with incorrect body balance [26].

Kratenová et al. [14] investigated the prevalence of postural deviation among children (7, 11, 15 years old). From 3520 subjects included in their study it resulted that because of lack of physical activity (measured by PAQ-c) 50% of children were detected with protruding scapulae, 32% with lumbar and 31% with round back. The preferred leisure-time form by children was watching TV and playing video games, for which they devoted 14 hours weekly. Children reported that they spent only 4 hours per week participating in different sports activities. In this study it is underlined that 20% of those who reported no participation in sports activities were at a greater risk of poor posture than children who regularly attend sports activities.

The above facts also confirm our findings in terms of perception and improvement of the postural stereotype of posture as an external manifestation of the functionality of the muscular system. Ultimately, movement stereotypes and their proper implementation play an important role. The presented findings showed significance of care for the postural health of pupils in physical and sport education. It is the consciously controlled correct motion patterns that are the basis for their possible reprogramming. However, this requires a longer time horizon. Every positive change is evaluated positively. It follows from the above that regular physical activity has its place and position in the movement regime of pupils in terms of postural health support [8, 24].

In terms of primary prevention of musculoskeletal system diseases, which is one of the determinants of health, physical and sport education requires interventions [10] in the form of health-oriented exercise programmes, which help to improve body posture (postural stability), functions of the spine and the muscle system in school-aged children [2, 4, 19, 21, 26, 29], to support their adequate development and improve quality of their health at present and in the future.

Conclusions

Due to physical and sport lessons according to the content of the school curriculum during period $V_{(1–2)}$ there were no significant changes ($p > 0.05$) in any of the evaluated areas of the musculoskeletal system (body posture, muscular system), the changes were only minimal. However, in the experimental period $V_{(3–4)}$ applying the ACT method to physical education and sport lessons, we noticed $V_{(3–4)}$ significant changes in W_{test} ($p < 0.05$) in terms of overall body posture and the muscular system, as well as manifestation of its functionality. We also noticed a significant difference in the monitored factors between periods $V_{(1–2)}$ and $V_{(3–4)}$ as reflected in the Mann–Whitney test ($p < 0.05$). This results in the fact that correctly selected and applied health-promoting exercises had a positive effect on the overall adjustment, improvement and quality of body posture and muscular system in pupils, which we evaluate very positively.

Based on the results of the experiment, we may recommend targeted exercises for practical use in physical education and sport lessons for the static load compensation system and prevention of functional disorders of the musculoskeletal system. However, it is important for the exercises to be carried out on a long-term and regular basis. Suitable conceived and focused programmes of exercises are crucial as part of physical education and sport lessons in the current hypokinetic way of life of people. They are indispensable for good quality of body posture health.

Conflict of Interest

The authors declare no conflict of interest.

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Influence of consequences of anti-pandemic measures in connection with the spread of coronavirus COVID-19 in the Czech Republic on selected body composition and performance parameters of children of younger school age

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Abstract
Introduction. **During the global COVID-19 pandemic, there has been a long-term and unprecedented reduction in physical activities.** Aim of Study. **The objective of the work was to describe specific changes in performance and body composition after long-term restrictions on mobility due to the COVID-19 pandemic in the group of young school children in the Czech Republic, which experienced one of the longest periods of closed schools and therefore restricted sports and leisure activities in the world.** Material and Methods. **This was a longitudinal study on an identical group of first-grade students (n = 52). The level of physical performance was repeatedly tested during the normal regime without any restrictions and after their return to school. The conducted test (standing long jump, shuttle run, sit and reach, sit-up test, endurance run) included also anthropometric measurements (weight, height, body fat content).** Results. **There was an increase in body fat by 64.23% (MD = 16.65 ± 2.73 cm; d = 0.85), increase in BMI values by 10.91% (MD = 1.77 ± 0.19 kg·m^{-1}; d = 1.29), as well as a significant decrease in endurance running by 14.6% (MD = 58.56 ± 9.32 s; d = 0.71) and in the flexibility test (sit and reach) by 250% (MD = 6.04 ± 0.75 cm; d = 1.12). For standing long jump and shuttle run the post-lockdown testing showed performance to improve in absolute terms, with children remaining in the given categories compared to the norms, usually around the population average of the given category. In the sit up test the performance scores did not change, an non-significant improvement of two exercises was recorded, but when comparing average performance results with the norms the performance deteriorated.** Conclusions. **The long-term restrictions on the normal exercise regime had a devastating effect on key components of performance and health-oriented fitness.**

KEYWORDS: children, COVID-19, body composition, health related fitness.

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Introduction

During the global COVID-19 pandemic there was a long-term and unprecedented reduction in physical activities. Not only were organized leisure activities restricted or directly banned to a greater or lesser extent, but the normal movement regime also changed significantly due to the nature of the restrictions. Walking to work, to school, moving around the workplace or school buildings, to shops, trips, walks was limited.
In the Czech Republic, teaching at primary schools was transferred to the distance teaching regime for the first time on March 11, 2020. First grade children returned to school on February 25, 2021. The next school year began with standard full-time teaching on September 1, 2021. Due

to the deteriorating epidemiological situation, various measures were gradually taken; a ban on physical education (as well as music lessons) was imposed in early October. From October 14, 2020 schools were completely closed and teaching was fully transferred to the online form. Since the end of November there was the so-called "rotational teaching" regime for some grades, when classes attended school in rotation. From the beginning of January, a widespread transition to online teaching was ordered again. Online teaching lasted until April 12, when some grades began to operate in the rotating teaching mode. All primary school pupils returned to school on May 24, 2021.

Anti-pandemic restrictions have affected the content and forms of physical education. Even in the weeks when pupils were allowed to stay in schools, it was accompanied by a number of measures and restrictions: wearing masks, restrictions on teaching (physical education and music education), movement only in fixed groups, etc. For a more detailed overview of school closures and types of teaching, see Table 1.

During online teaching, the issue of physical education was generally addressed only marginally. Due to the recommendation not to overburden students with excessive time spent at the computer monitors, music and physical education were often completely discontinued by the regulations of the school management, or the fulfillment of tasks in these subjects was only on a voluntary basis. During physical education lessons teachers most often included challenges or joint online exercises usually focused on the development of strength and flexibility ("workout", "stretching"), some schools or specific teachers did not teach physical education, or education in general at all [13].

Measures affecting leisure activities always copied the situation in schools being imposed with a slight advance or delay. Gradual reduction or release was always accompanied by various restrictions concerning the place (only outside, in a specified area), the number of people or the organization of exercises (spacing, not using equipment, the trainer or coach wearing a mask, etc.). These regulations changed very often and quickly,

Table 1. Detailed overview of types of teaching in individual phases of pandemic in the Czech Republic

1st wave	11.3.–11.5.20	11.5.–25.5.20	25.5.–1.6.20	1.6.–8.6.20	8.6.–26.6.20
1st – 2nd grade	distance	distance	full-time	full-time	full-time
3rd – 5th grade	distance	distance	full-time	full-time	full-time
6th – 8th grade	distance	distance	distance	distance	distance
9th grade	distance	rotating	rotating	rotating	distance
Special classes	distance	distance	distance	full-time	full-time
2nd wave	14.10.–18.11.20	18.11.–30.11.20	30.11.20–4.1.21		
1st – 2nd grade	online	full-time	full-time		
3rd – 5th grade	online	online	rotating		
6th – 8th grade	online	online	rotating		
9th grade	online	online	rotating		
Special classes	online	full-time	full-time		
3rd wave	4.1.–1.3.21	1.3.–12.4.21	12.4.–24.5.21		
1st – 2nd grade	full-time	online	rotating		
3rd – 5th grade	online	online	rotating		
6th – 8th grade	online	online	online		
9th grade	online	online	online		
Special classes	full-time	online	full-time		

Note: distance – partly online, partly fulfillment of submitted tasks; full-time – according to timetable (except PE, ME, Art); online – only online classes according to adjusted timetable (without PE, ME, Art); rotating – half of the class at school according to timetable, the second half online with a number of exceptions, and they were difficult to follow and observe by all those involved. At the time of the strictest lockdown travel between districts and movement between individual municipalities was also restricted; these measures also interfered with seemingly permitted leisure activities, such as hiking, skiing, or cycling. The period of time, during which schools in the Czech Republic were restricted in their operation was the longest in comparison with other countries in the world.

A vast majority of research conducted to date on the impact of a pandemic situation on physical activity, performance and physical parameters have used online self-reporting questionnaires as a research method [5, 10, 14, 16, 19], a smaller number of studies applied a revolving panel design [1, 2, 4, 17] and to a lesser extent – in the order of units, researches with a longitudinal panel design are represented [6, 8, 17, 21]. Some studies also used data mining using wearables (watches, fitness bracelets, applications in mobile phones) [11].

The parameters that were monitored and evaluated in these studies include body composition in terms of assessing the increase in obesity, specifically BMI. This phenomenon has been observed worldwide. Jarnig et al. [6], found that in the observed group of Austrian children aged 7-10 years there was an increase in the number of overweight or obese children by 4% during the year, overall there was a more significant deterioration in boys. Wahl-Alexander et al. (USA) [21] recorded an increase in BMI in children by 10.6%. A meta-analysis by Chang et al. [3] showed significant increases in body weight gain (mean difference, MD = 2.67, 95% CI = = 2.12–3.23; $p < 0.00001$) and BMI (MD = 0.94, 95% CI = 0.32–1.56; $p = 0.003$) during lockdown among school-age children and adolescents. The prevalence of obesity and overweight also increased. The results presenting the conclusions of the research on this topic are summarized in Table 2.

The decrease in the level of health and performance-oriented fitness parameters is certainly due to the reduced level of physical activity during lockdown. As presented by Štveráková et al. [16], even countries with a much shorter school leaving period than the Czech Republic, such as France (lockdown for 11 weeks), Portugal (24 weeks) or Spain (15 weeks), confirmed the reduced level of physical activity in children during the COVID-19 pandemic and called for the development of effective national measures. For example, in Slovenia during the pandemic there was the most substantial decline in physical fitness in the course of 30 years. The deterioration occurred despite the efforts of the state authorities and aggressive campaigns to support physical activity at the time of the ordered social isolation [7]. Based on the results of questionnaires and data from accelerometers, a significant decrease in physical activity against the norm was also recorded in Czech children. Decreased physical activity is certainly one of the reasons for the increase in the number of overweight or obese people. However, not only a significant restriction of exercise, but for example a change in the diet had

Table 2. Overview of research related to the influence of a pandemic situation on motoric performance and physical parameters

Authors / Dependent samples	n, age	Measured parameters and results	Country
Wahl-Alexander, 2021 [21]	264, 9–14	BMI +10.6%; PU –35.6%; SU –19.4%; SRT –26.7%	USA
López-Bueno, 2021 [8]	89, 13.3 ± 0.9	VO_2max from SRT –0.64	ESP
Jarnig, 2021 [6]	764, 8.3 ± 0.7	BMI +2.2%; OO +3.8%; ER(6 m) –7.2%	AUT
Sunda, 2021 [17]	66, 15.6 ± 0.51	SU –21.4%; ER(600 m) –29.1%	CRO
Independent samples			
Dayton, 2021 [4]	10, 14.5, 15.2	VO_2max – direct –12.5%	USA
Chambonnière, 2021 [2]	206, 9.9, 9.4	SLJ –20%; MBT –17.1%; SRT –54.1%	FRA
Berisha, 2021 [1]	41, 16.0 + 0.5	SU –18.7%; PU –0.47%; MBT –7.31%	RKS
Sunda, 2021 [17]	48, 15.3 + 0.3	SU –8.3%; ER(600 m) –10.4%	CRO
Tsoukos, 2022 [18]	293, 15.8 ± 0.3	OO +22.1(M), +18.6(F); VJ –15.1, S –4.9%	GRE

Note: PU – push-ups; SU – sit-ups; SRT – shuttle run test; OO – obesity overweight; ER – endurance; SLJ – standing long jump; MBT – medicine ball throw; VJ – vertical jump, S – sprint

an effect. The absence of a suitable and balanced diet, which is at least partially provided by school meals in the normal education regime, manifested itself [15].
The aim of this work was to quantify what specific changes occurred in the various components of motoric performance, and how the body composition changed, in terms of the amount of subcutaneous fat after a long-term absence of exercise regime in the monitored group of children of younger school age in the Czech Republic, which had one of the longest periods of closed schools and restricted sports leisure activities in the world. With these findings we want to contribute to the existing knowledge dealing with the impact of restrictions on the movement regime in connection with the global pandemic of COVID-19.

Material and Methods

Participants
We performed testing on a group of younger school-age children, who were tested in another research shortly before the first wave of the COVID-19 pandemic [20]. As part of this survey we performed basic anthropometric measurements and performance testing. We used the obtained data as a basis for current research in the same group of children, in relation to some of them, where the situation allowed, we repeated these same measurements after the COVID pandemic subsided. The research group consisted of third graders at the elementary school in Brandýs nad Labem. A total of 52 children were included in the study, for whom it was possible to ensure complete results in both measurements. Of the total number, there were 20 girls and 32 boys.

Procedures
A series of tests based on the UNIFITTEST 6-60 test battery was used to evaluate the level of motor performance [9]. Tests used from this battery included standing long jump (feet closing), sit-downs repeatedly and shuttle run 4 × 10 meters. These tests were supplemented with a sit and reach test and 1000 m run. Somatic measurements of body height and weight were performed on probands and from the results the BMI was calculated. Body composition, in terms of the amount of subcutaneous fat was determined using calipers – measuring the thickness of 3 skin folds (tricipital, subscapular and suprailiac).
There was a time interval of 19 months between the first and second measurements. The first measurement took place in the autumn of 2019, at that time the children were at the beginning of the 3rd grade and their average age was 8.38 ± 0.71 years. The second measurement took place in the spring of 2021, after the schools reopened. The observed group of children was at the end of the 4th grade, the average age of the children reached 9.98 ± 0.69 years. Extensive restrictions on full-time education were applied to children (Figure 1).

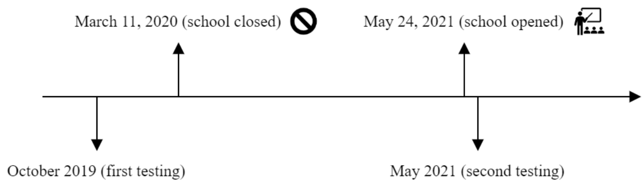

Figure 1. Study schedule

Statistical analysis
A prerequisite for further work with the data was the description of the research file in order to find the basic characteristics of the monitored variables both in the whole research group and in groups divided by gender, so that it was subsequently possible to make a comparison of performances with respect to the standards for a given age group. To determine intra-individual differences, both data sets were compared by a pairwise test (Student's t-test, a priori Shapiro–Wilk test). By comparing the results we determined the significance of differences in individual components of motor performance in the observed group of children. Given that this was an occasional non-random selection, the material significance of the difference was determined for all the parameters (Cohen's d). Data referring to averages were compared with the Unifittest [9] reference standards for a given age group and gender. We did not use the conversion to the standardized score, because a number of performances were in the range of the lowest points already during the first testing and a possible change in these cases could not be recorded at all.

Results

Compared to the amount of subcutaneous fat (Table 3), there was an increase of 64.23%. The difference found corresponds to a large effect of material significance (d = 0.85). When compared to the standards for a given age category, the values of the amount of subcutaneous fat found in the first test averaged 3 points (from a 5-point scale). In the second testing, the values found were already above average, resp. very high (4 points). BMI increased by 1.77 ± 0.19 kg·m^{-1}. The difference found corresponds to a large material effect (d = 1.29). While BMI values in the first measurement were in both genders at approximately the 60th percentile for a given age group, in the second measurement the values moved to 77th percentile (boys) and 75th percentile (girls). The percentage increase is 10.91%.

The results of the sit-downs test (Table 4) showed stagnation in absolute values, resp. there was an improvement of only 2 repetitions on average, but the difference found has only a low level of material significance (d = 0.27). When compared to the standards listed for a given age category, the performances of the entire study group remain in the average category (boys 5 points before and after, girls 6 points before and 5 points after).

In the jump test, the children improved by 24.40 cm on average (MD = 24.40 ± 2.57 cm; d = 1.32). There was an improvement not only in absolute values, but also when comparing the relative values of performances converted to standardized points for a given age category (boys 3 points before, 5 points after, girls 4 before and 5 after). The results of the sit and reach test indicate a worsening of flexibility in the observed group of probands. The observed difference in the performance of the first and second testing for sit and reach test was factually significant (MD = 6.04 ± 0.75; d = 1.12). Compared to the recommended standard [19], performances in the

Table 3. Basic anthropometric data and parameters of physical characteristics of boys (n = 32), girls (n = 20) and overall (n = 52)

	Gender	Age [yrs]		Height [cm]		Weight [kg]		Fat [mm]		BMI [kg·m^{-1}]	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
M	boys	8.29	9.91	134.00	144.00	30.40	38.90	25.50	45.00	16.70	18.60
SD		0.76	0.73	7.02	7.53	7.67	10.80	17.90	23.60	2.72	3.46
ES(d)								1.02		1.27	
M	girls	8.31	9.93	131.00	141.00	27.80	35.40	26.90	39.00	16.20	17.70
SD		0.66	0.65	6.35	6.90	4.66	6.36	13.80	28.00	1.90	2.37
ES(d)								0.60		1.43	
M	all	8.30	9.92	133.00	143.00	29.40	37.60	26.00	42.70	16.50	18.30
SD		0.71	0.69	6.94	7.35	6.75	9.43	16.30	25.30	2.43	3.09
ES(d)								0.84		1.29	

Note: 1st – first (pre-lockdown) testing; 2nd – second (post-lockdown) testing; ES(d) – effect size (Cohen's d)

Table 4. Performances of boys (n = 32), girls (n = 20) and overall (n = 52) in single motoric tests, including an assessment of the materiality of the differences.

	Gender	Sit-ups [rep]		Jump [cm]		Sit-reach [cm]		Shuttle [s]		1000 m run [s]	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
M	boys	28.20	31.00	121.00	148.00	1.72	–4.88	14.90	12.90	335.00	396.00
SD		10.00	7.35	18.30	18.80	8.12	8.50	1.63	1.88	64.10	116.00
ES(d)		0.36		1.39		1.18		1.35		0.92	
M	girls	29.80	30.40	127.00	148.00	6.55	1.40	14.60	12.90	356.00	410.00
SD		7.87	8.99	21.10	19.60	7.58	9.84	1.21	1.34	66.30	108.00
ES(d)		0.09		1.24		1.08		1.12		0.79	
M	all	28.80	30.80	123.00	148.00	3.58	–2.46	14.80	12.90	342.92	401.48
SD		9.19	7.94	19.50	18.90	8.20	9.46	1.47	1.68	65.20	112.00
ES(d)		0.27		1.32		1.12		1.26		0.87	

Note: 1st – first (pre-lockdown) testing; 2nd – second (post-lockdown) testing; ES(d) – effect size (Cohen's d) first test were just below the lower limit of the average, in the second they were significantly below average.

In the 4 × 10 m shuttle run test children on average accelerated (MD = 1.9 ± 0.21; d = 1.26). There was an improvement in absolute terms, even considering performance with respect to age. Compared to the standards, there was a shift from the category of significantly below average to the category of average (boys 1 resp. 5 points, girls 2 resp. 5 points).

There was a significant deterioration in aerobic endurance testing, which was tested using the 1000 m run test. The run time deteriorated by an average of 14.6% (MD = = 58.56 ± 9.32; d = 0.87). The materiality factor indicates a great effect.

Discussion

The COVID-19 pandemic has had a significant impact on a number of areas, although it has been and still is a priority to reduce proliferation and prevent loss of life. The restrictions that the measures entail have a longer-term impact on children's health. Only through a completely lay assessment from the point of view of parents, coaches, and teachers the changes took place. With this work, we wanted to contribute to the transition from the level of assumptions to the level of facts. Although this is a relatively small sample, the results suggest a negative trend, the effects of which we will most likely face in the years to come. We followed the performance of a selected group of young school-age children, which we tested in the fall of 2019 and then in the spring of 2021, immediately after the release of the measures that had been taken due to the spread of COVID-19. Under normal circumstances, it would be expected to see improvement of physical test results in absolute terms and with increasing age. In the relative assessment of the results with respect to age, the results should not change significantly. The ratio of the fat component should remain practically the same at this age, the expected increase usually comes later with the coming puberty.

When measuring and comparing the results of our sample, we found out that after the COVID pandemic and the long-term closure of schools and restrictions on leisure activities, there were significant negative changes in body composition with a significant increase in fat and BMI. These findings are consistent with the results of similar researches [6, 21]. In this context, it is necessary to draw attention to the limits of the BMI value, the interpretation of which is especially problematic in the pediatric population, as it does not take into account growth specifics and biological age [12].

We noticed a significant deterioration in the results of flexibility and aerobic endurance tests. This can be attributed to the forced change of movement regime, when physical activity decreased significantly (natural walking, etc.) and the time spent at the computer increased (online teaching and online social contacts). The observed deterioration in aerobic fitness corresponds to the results of all other researches [6, 8, 17, 21] whereas the deterioration we detected is one of the most significant.

Surprisingly, the increase in the fat component did not result in a deterioration in speed or strength. The results of the jump tests and the shuttle run tests improved in absolute and relative terms. The sit up tests results are practically at the same level. It is possible that the teachers of the researched group of children motivated them to exercise at home, which included mainly exercises for strength development (skipping rope, small workout with their own weight and home aids). In these findings, we therefore differ from the results in the United States [17] in terms of strength and endurance tests. The reason may be partly another age cohort, partly different testing methodology or different cohorts studied (dependent versus independent samples) [2]. Physical abilities that are less trainable, resp. more affected by genetic predispositions were not so much affected by the failure of the exercise regime.

It would certainly be beneficial to monitor the interim results as well. The original plan was testing after the first wave and a relatively shorter closure in the autumn of 2020. Unfortunately, the schools were closed very quickly and unexpectedly, and this plan was unfortunately not possible to implement.

The teachers of our monitored classes also regularly gave children movement "tasks", they practiced online with their children, they mainly focused on small coordination exercises. They also focused on strength training exercises (weight training, skipping, etc.) and compensatory exercises. The school regularly published sports challenges and distance movement competition between classes. The school tried to support the children to move. Based on personal contacts and statements of children and parents, we know that many families have tried to replace the absence of physical education and sports activities by doing family walks or outdoor sports. However, the results suggest that the effect was not nearly as large as expected. It can be assumed that the restrictions adopted caused such a significant and fundamental change in the movement regime, which could not be sufficiently compensated despite considerable efforts. This subsequently led to a significant change in body composition, i.e., an increase in both the fat component and BMI values and a deterioration in the aerobic part of physical fitness. We may trace the manifestation in the areas of motivation, attitudes, psyche later on.

Conclusions

After evaluating the measured results, it was found that in the case of the amount of subcutaneous fat there was a significant increase in values, compared before and after the lockdown break (MD = 16.65 ± 2.73 mm; d = 0.85). We also detected higher values in BMI (MD = 1.77 ± 0.19 m·kg^{-1}; d = 1.29). From the tests determining the parameters of health and performance-oriented fitness, there was a significant deterioration in the endurance run at 1000 m (MD = 58.56 ± 9.32 s; d = 0.87) and in the test, i.e., the sit and reach test, which determined flexibility (MD = 6.04 ± 0.75; d = 1.12). The improvement occurred in the jump test (MD = 24.40 ± ± 2.57 cm; d = 1.32) and shuttle run 4 × 10 m (MD = = 1.9 ± 0.21; d = 1.26) both in absolute terms and when comparing the results with the standards for a given age category.

There was only a slight improvement in the sit up test (MD = 2 ± 1.03; d = 0.27), performance stagnated in terms of age, in girls they were slightly worse compared to the results before the lockdown. The results of our study are comparable with similar research abroad. However, there are currently not enough primary studies to assess the hypothesis that the time of school closure in the Czech Republic, which was unprecedentedly the highest in the world, correlates with the rate of decline in the parameters of health and performance-oriented fitness.

Conflict of Interest

The authors declare no conflict of interest.

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Changes in weight and body composition in physically active first year university students

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Abstract

Introduction. **Previous studies showed that transition to university may pose a risk of weight gain among first year university students. However, researchers have overlooked to examine students with unique characteristics that might vary their susceptibility to weight gain.** Aim of Study. **The purpose of this study was to examine changes in body weight and body composition among physically-oriented first-year students.** Material and Methods. **A total of 86 physically active first year students participated in the study. Students' body weight and other body composition variables were measured at three time points during their first year in university.** Results. **Overall, while no significant weight gain was found in first year students at the end of the study compared to the baseline, their average weight gain was lower than earlier findings. However, significant changes in % body fat of students were observed during their freshman year. Both male and female students experienced transitory changes in weight, fat mass, % body fat, and % skeletal mass during the study. Among the total cohort of students, more than 50% gained weight after 7 months in their freshman year despite their high level of physical activity participation.** Conclusions. **This study extends the literature concerning weight gain during transition from school to university among first year students and its association with physical activity. It also shows the potential role of culture affecting the incidence of weight gain in freshman students. Finally, the finding highlights the importance of weight gain prevention programs for first-year university students, even if they are physically active.**

KEYWORDS: physical activity, weight gain, South Korea, physically-oriented students, Freshman 15.

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Introduction

Transition to university is found to be associated with changes in lifestyles of students. Changes in lifestyle can involve the adoption of unhealthy behaviors such as eating too much foods high in fat or sugar [5, 10], drinking excessive amounts of alcoholic drinks and/or sugary beverages [24], and being physically inactive [25]. When these unhealthy behaviors are not properly regulated, it can potentially lead to weight gain in students and consequently increase their risk in developing weight-related health problems such as overweight, obesity, stroke, and diabetes [28].

Empirical studies on weight gain in university students are well-documented particularly during the first year of university [3, 9, 10, 12, 14, 17, 20], since transitioning from high school to university is considered a critical period for weight gain [23]. For instance, Lloyd-Richardson et al. [17] found that female students gained an average weight of 1.6 kg, while male students got heavier by 2.5 kg during their freshman year. Levitsky et al. [15] reported that female freshmen students gained 3.1 ± 0.51 kg and 2.0 ± 0.65 kg of weight in the first semester of 2002 and 2003, respectively. Meanwhile, Finlayson et al. [10] revealed that body weight (0.83 ± ± 2.1 kg) of first year students significantly increased between the baseline and 3 months. Other body composition measures were also found to increase, including BMI (0.29 ± 0.72 kg/m^2) and fat mass

(0.88 ± 1.87 kg). Recently, Olansky et al. [20] found that freshmen students gained body weight (3.2 ± 3.8 kg), fat mass (2.5 ± 3.0 kg), and % body fat (2.3 ± 4.9%), while also lean body mass (0.7 ± 2.1 kg) increased at the end of their first year of university. The results from these studies indeed showed the prevalence of weight gain in first year university students and researchers reported that students' weight gain was due to lifestyle changes associated with transition to university.

However, a majority of these findings came from samples of students from western countries and thereby a lack of information on weight gain of first year university students from other nations. Secondly, while studies found weight gain in first year students, the findings showed disparities in terms of the degree of weight change during the freshman year and therefore need further exploration. Thirdly, previous studies mainly assessed changes in body mass/weight to represent gain or loss of fat mass, but only few reported other measures of body composition found to be relevant not only in determining weight change, but also in evaluating health status of students [10, 20]. Finally, given that physical activity has been shown to prevent weight gain or maintain weight [25, 27], it is plausible to argue that students who are physically active or achieving the recommended level of physical activity of at least 150-300 minutes of moderate-intensity or at least 75-150 minutes of vigorous-intensity aerobic physical activity per week [29] are likely to maintain their weight or avoid weight gain. This might not be a concern for freshmen students pursuing a degree in physical education (PE)/kinesiology, since they are known for being physically active [1, 2, 29]. More so, classes in their first year normally compel them to engage in various forms of sports and exercises and thus they are expected to meet the recommended physical activity level and consequently maintain weight or avoid weight gain. On the other hand, despite being physically active, these students might still be at risk of weight gain considering that they may also potentially practice other unfavorable lifestyle changes when transitioning to university life. However, there is a dearth of empirical studies related to weight changes in specific groups of university students, particularly those students who are physically active or who are attaining the suggested physical activity level requirements during their first year of university.

Therefore, given the limitations of previous studies and research gap in the literature, the objective of this study was to examine changes in body weight and other relevant body composition variables in a specific group of first-year university students. Specifically, the aim was to examine body composition changes of physically active Korean male and female students during their freshman year. This study bridges a knowledge gap regarding weight change in first year university students from a different nation and provides empirical support concerning weight and body composition changes in a specific group of students who may be less susceptible or resistant to weight gain. Finally, the findings may be used to create appropriate interventions that aim to prevent students' weight gain, which has key implications for students' future health [27].

Material and Methods

Participants

A total of 109 students participated in the study. All participants were first year university students in a private university in Korea. They were freshmen students at the College of Physical Education who majored in physical education (n = 22), sports for all (n = 40), sport marketing (n = 1), and taekwondo (n = 46).They were recruited by word of mouth and advertisements from each department website. Participants who volunteered were reminded via email and university's short messaging system about the date and time of the tests. Students were assumed to achieve the recommended level of physical activity per week, for they were required to attend 2-hour practical classes per week during their freshman year, including swimming and track and field, and racket/ball sport. Aside from attending these physical activity classes, a majority of students reported that they were members of different sport clubs such as soccer, basketball, badminton, and tennis with a 2-3 hour session, once or twice a week training schedule. Hence, these physical education major students were accumulating at least 360 to 480 minutes of moderate and vigorous intensity physical activity per week, which qualify them within the physically active category.

From the total sample, 23 students were excluded for missing the remaining one or two testing periods either due to the mandatory 2-year military service for male students or non-appearance. Therefore, 86 first year students (55 men and 31 women; aged 18-22 years) from physical education (n = 19), sports for all (n = 27), and taekwondo (n = 40) were included in the final analysis.

Data collection

Participants' height was measured to the nearest 0.1 cm using a portable stadiometer (Donghwa Science; Korea) consisting of an anthropometer with a simple headboard by trained research assistants. Body weight, body fat mass, skeletal muscle mass and body fat percentage were measured using bioelectric impedance analysis (InBody 502; Korea). Height and body composition were measured with bare feet with light clothing after removing all metallic objects. Using the measured height and body weight values, BMI was calculated as weight (kg) divided by height (m) squared.

Procedure

Prior to data collection, the appropriate sample size and power were calculated using G*Power. The following values were encoded based on the required input parameters to calculate the total sample size: 1) partial eta squared (η_p^2) = 0.14 assumed to be large effect size; 2) type 1 error probability rate = 0.01; 3) level of statistical power = 95%; 4) number of groups = 2; 5) number of measurements = 3 (time points). Based on the result, 30 participants were needed to determine the minimal detectable effect. The number of participants in this study therefore was more than the required sample size.

Data were collected longitudinally at three points: the beginning of the first semester (March), the end of the first semester (June), and the beginning of the second semester (September). All anthropometric (height, weight) and body composition measurements were performed in the morning (08:00-10:00). Students were instructed not to drink alcohol or caffeine 10-12 hours and not to eat 2-4 hours before testing to increase the accuracy of body composition assessment.

Consent were obtained from all participants and procedures were conducted in accordance with relevant ethical guidelines stated in the Declaration of Helsinki and local ethics board [13, 30].

Statistical analysis

Descriptive statistics (means ± standard deviations, minimum and maximum values) were initially analyzed to check for parametric assumptions. Tests for normality using the Kolmogorov–Smirnov test of all outcome variables were non-significant and thereby followed a normal distribution. Weight and other body composition variables for all students and for male and females at all three periods were examined via repeated-measures analysis of variance. Moreover, the difference between T1 and T3 of weight and selected predictors of weight were calculated. The computed scores were used to categorize male and female participants into gainers, maintainers, or losers before conducting chi-square tests (χ^2) to examine potential differences in distribution. All analyses were conducted using SPSS 25 for Windows (IBM, Armonk, NY, USA). Significance was set at $p < 0.05$.

Results

Summary of first year students' relevant outcome measures are presented in Table 1. Overall results showed significant changes in average weight, % body fat, % skeletal mass, fat mass, skeletal mass, and BMI in first year students across three time points. A repeated measures ANOVA with a Greenhouse–Geisser correction showed that mean weight [$F(1.79,152.38) = 3.92$, $p < 0.05$, $\eta_p^2 = 0.04$], % body fat [$F(1.66,141.380) = 16.02$, $p < 0.001$, $\eta_p^2 = 0.16$], % skeletal mass [$F(1.52,129.84) = 6.65$, $p < 0.01$, $\eta_p^2 = 0.07$], fat mass [$F(1.56,132.96) = 9.28$, $p < 0.001$, $\eta_p^2 = 0.10$], and BMI [$F(1.34,113.87) = 5.41$, $p < 0.01$, $\eta_p^2 = 0.01$] differed significantly between time points.

Post hoc tests using the Bonferroni correction revealed that mean weight was higher for T3 compared with T2

Table 1. Changes in weight and body composition of first year university students

N	Time	Variable	Mean	SD	Min	Max	p
overall	time 1	weight (kg)	66.21	10.49	44.10	97.90	0.026
n = 86	time 2		65.90	10.29	45.10	100.00	c
	time 3		66.52	10.54	44.80	105.60	
	time 1	fat mass (kg)	12.40	4.45	3.60	28.00	0.001
	time 2		12.11	4.85	4.30	28.60	phoc nsd
	time 3		13.13	4.78	4.50	29.00	
	time 1	skeletal mass (kg)	30.32	6.31	18.60	45.00	0.628
	time 2		30.32	6.22	18.60	46.00	
	time 3		30.24	6.31	18.70	46.80	

	time 1	% body fat*	18.91	6.69	5.40	36.30	0.001
	time 2		18.41	7.06	6.40	36.90	a, b, c
	time 3		19.65	6.92	6.80	37.40	
	time 1	% skeletal mass**	45.54	4.35	35.54	54.12	0.004
	time 2		45.78	4.64	35.10	53.33	c
	time 3		45.22	4.72	34.66	58.89	
	time 1	BMI (kg/m^2)	22.72	2.42	18.20	27.70	0.014
	time 2		22.63	2.39	18.00	28.00	phoc nsd
	time 3		22.98	2.47	18.20	29.60	
Male	time 1	weight	71.56	7.55	56.60	97.90	0.014
n = 55	time 2		70.97	7.75	58.50	100.00	c
	time 3		71.91	7.82	59.20	105.60	
	time 1	fat mass	11.10	3.91	3.60	19.60	0.001
	time 2		10.47	4.28	4.30	20.00	a, c
	time 3		11.86	4.55	4.50	24.00	
	time 1	skeletal mass	34.42	3.36	27.70	45.00	0.962
	time 2		34.39	3.19	28.80	46.00	
	time 3		34.38	3.27	27.60	46.80	
	time 1	% body fat*	15.17	4.49	5.40	23.80	0.001
	time 2		14.45	4.77	6.40	24.80	a, c
	time 3		15.85	4.84	6.80	25.20	
	time 1	% skeletal mass**	48.20	2.60	42.47	54.12	0.017
	time 2		48.61	2.81	42.48	53.33	a, c
	time 3		47.97	3.22	42.47	58.89	
	time 1	BMI (kg/m^2)	23.30	2.23	19.50	27.70	0.024
	time 2		23.09	2.30	19.10	28.00	phoc nsd
	time 3		23.57	2.34	18.80	29.60	
Female	time 1	weight	56.72	7.96	44.10	77.10	0.649
n = 31	time 2		56.91	7.84	45.10	77.50	
	time 3		56.96	7.57	44.80	77.60	
	time 1	fat mass	14.71	4.46	8.40	28.00	0.195
	time 2		15.03	4.47	8.30	28.60	
	time 3		15.38	4.38	9.30	29.00	
	time 1	skeletal mass	23.05	2.63	18.60	28.60	0.281
	time 2		23.09	2.67	18.60	28.40	
	time 3		22.88	2.50	18.70	27.20	

time 1	% body fat*	25.53	4.46	18.20	36.30	0.023
time 2		25.44	4.49	18.00	36.90	phoc nsd
time 3		26.39	4.46	18.00	37.40	
time 1	% skeletal mass**	40.82	2.35	35.54	45.18	0.088
time 2		40.75	2.42	35.10	45.05	
time 3		40.35	2.48	34.66	44.90	
time 1	BMI (kg/m^2)	21.68	2.42	18.20	27.20	0.217
time 2		21.80	2.36	18.00	27.20	
time 3		21.94	2.38	18.20	27.30	

Note: a = T1 vs T2; b = T1 vs T3; c = T2 vs T3; phoc nsd = post hoc no significant difference, * fat mass/weight; ** skeletal mass/weight

(66.52 kg vs 65.90 kg). Mean % body fat for T3 was higher than T1 (19.65% vs 18.91%) and T2 (19.65% vs 18.41%), while mean % body fat for T2 was lower than T1 (18.41% vs 18.91). Mean % skeletal mass for T3 was lower than T2 (45.22% vs 45.78%). Fat mass and BMI mean scores between all three time points did not show significant differences.

For skeletal mass, repeated measures ANOVA showed no significant differences between time points [F(1.84,156.85) = 0.44, p = 0.62] (Table 1).

Weight and body composition changes in freshmen male students

Repeated measures ANOVA results showed that male students' average weight [F(1.73, 93.42) = 4.79, $p < 0.01$, $\eta_p^2 = 0.08$], % body fat [F(1.54,83.46) = 13.11, $p < 0.05$, $\eta_p^2 = 0.20$], % skeletal mass [F(1.38,74.67) = = 5.13, $p < 0.05$, $\eta_p^2 = 0.08$], fat mass [F(1.28,69.41) = = 9.68, $p < 0.05$, $\eta_p^2 = 0.15$], and BMI [F(1.29,69.68) = = 4.76, $p < 0.05$, $\eta_p^2 = 0.08$], differed significantly between time points.

Post hoc pairwise comparisons using the Bonferroni correction revealed that mean weight for T3 was higher than T2 (71.91 kg vs 70.97 kg). Mean % body fat for T1 was higher than T2 (15.18% vs 14.45%), whereas mean % body fat for T3 was higher than T2 (15.85 vs 14.45%). Mean % skeletal mass for T2 was both greater than T1 (48.61% vs 48.20%) and T3 (48.61% vs 47.97%). Mean fat mass for T1 was higher than T2 (11.10 kg vs 10.47 kg), while mean fat mass for T3 was greater than T2 (11.86 kg vs 10.47 kg).

Skeletal mass mean scores between all three time points did not show significant differences.

After 7 months as freshman students, 60%, 5.5%, and 34.5% of men gained, maintained, and lost weight, respectively. Most men (72.7%) gained fat mass, while the rest 27.3% lost fat mass. Two-thirds (69.1%) of men gained skeletal muscle mass, while the other students either maintained (1.8%) or lost (29.1%) skeletal muscle mass. Based on the ratio between fat/skeletal mass and weight, more than one-third (38.2%) gained body fat percentage, while maintainers and losers accounted for 5.5% and 56.4%, respectively. However, a majority of male students lost skeletal mass relative to their weight (Figure 1). The observed differences in the distribution for weight ($\chi^2(2) = 24.58$, p = 0.01), fat mass ($\chi^2(2)$ = = 37.78, p = 0.01), skeletal muscle mass ($\chi^2(2) = 21.96$, p = 0.01), body fat percentage ($\chi^2(1) = 11.36$, p = 0.01), and skeletal mass percentage ($\chi^2(1) = 5.25$, p = 0.05 were all significant.

All in all, after 7 months as first year university students, male students showed changes in their weight, fat mass, and skeletal mass with an average of 0.35 kg, 0.76 kg, and –0.04 kg, respectively. The percentage of ratio between fat/skeletal mass and weight in male students also changed by 0.67% and 0.25% respectively (Figure 2).

Weight and body composition changes in freshmen female students

Repeated measures ANOVA results showed that only female students' % body fat [F(2,60) = 4.02, $p < 0.05$, $\eta_p^2 = 0.11$] different significantly between time points.

Post hoc pairwise comparisons using the Bonferroni correction revealed that mean % body fat scores for T1, T2, and T3 did not significantly differ between time points.

After 7 months as freshman students, 54.8%, 3.2%, and 41.9% of women gained, maintained, and lost weight, respectively. Nearly two-thirds (67.7%) of women gained fat mass, while the rest lost (29%) fat mass. Most women (65%) gained skeletal mass, while maintainers and losers were 6% and 29%, respectively. In terms of the ratio between fat/skeletal mass and weight, while more than half (58.1%) of women lost % body fat, most women (68%) also lost skeletal mass relative to their weight. The observed differences in distribution for weight ($\chi^2(2) = 24.58$, p = 0.01), fat mass ($\chi^2(2)$ = = 37.78, p = 0.01), skeletal muscle mass ($\chi^2(2) = 21.96$, p = 0.01), body fat percentage ($\chi^2(1) = 11.36$, p = 0.01), and skeletal mass percentage ($\chi^2(1) = 3.90$, p = 0.05) were all significant (Figure 1).

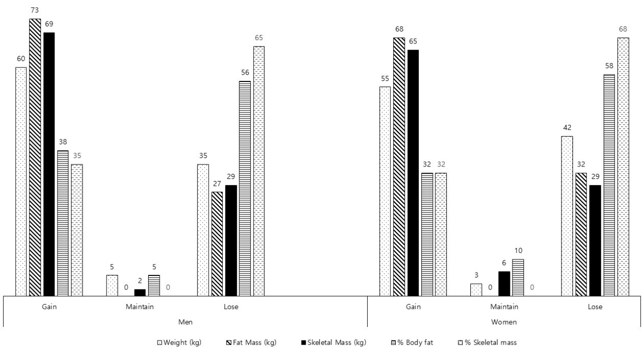

Figure 1. Percentage (%) distribution of changes in body composition characteristics between March and September among first year university students

Note: Positive number represent increased in that parameter.

All in all, after 7 months as first year university students, female students showed changes in their weight, fat mass, and skeletal mass with an average of 0.25 kg, 0.67 kg, and –0.16 kg, respectively. The percentage of the ratio between fat/skeletal mass and weight in female students also changed by 0.86% and 0.47% respectively (Figure 2).

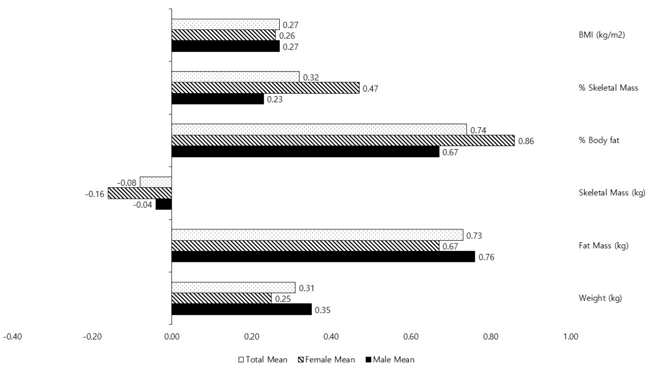

Figure 2. Changes in body composition characteristics between March and September among first year university students

Discussion

The current study examined changes in body weight and other body composition variables of the specific group of university students, particularly physically active Korean male and female students during their freshman year. Overall, a significant change in students' weight was found, but only between T2 and T3. That is, first year students gained a substantial amount of weight at the beginning of their second semester than at the end of the first semester in their freshman year. Students' % skeletal mass significantly changed between T2 and T3 as well. Specifically, students' skeletal mass percentage dropped 4 months after the end of the first semester. Finally, significant changes in % body fat of students were observed across the three time points. In particular, 7 months after the start of the first semester, first year students' % body fat showed a sharp rise, but not after an earlier transitory reduction in % body fat at the end of the first semester.

While students' overall mean weight increased after 7 months in their freshman year compared with their initial weight, the difference was not statistically significant. This result supports previous study [11], but also refutes other findings showing that students gained a significant amount of weight during their first year in university [12, 18, 22]. The discrepancy in the results may be attributed to the study participants, who were students from a specific major that were identified to be physically active. Decrease in PA or low PA during the freshman year has been found to be associated with weight gain. In this case, substantial gain in students' weight was likely prevented due to the active engagement of the students in various physical activities during their freshman year. It is also noteworthy to report that the 0.31 kg gain in the overall mean weight of physical education major students was lower compared with previously observed average values that ranged between 0.39 kg and 3.38 kg [7, 24, 25].

Physical activity participation is found to be associated with skeletal muscle mass [19]. That is, the more an individual participates in physical activities, the more skeletal muscle mass is likely to develop and vice versa. In this case, the decrease in students' % skeletal mass at the beginning of the second semester compared to 4 months earlier was likely due to the students' reduction in physical activity brought about by a break in the semester (summer). This findings therefore highlight the importance of consistent physical activity participation in maintaining skeletal mass in relation to weight and further supports the notion of muscle mass loss and detraining [4]. However, since the physical activity level was not assessed, it would be interesting to determine how much duration was reduced in students' physical activity level to further understand the association between physical activity and muscle mass.

Interestingly, significant changes in students' % body fat were found during the 7-month study. This finding indicates that first year students reduced their % body fat after the first semester. However, at the beginning of the second semester their % body fat increased considerably higher compared with the baseline score. Despite the significant increase in overall mean % body fat of freshman students after 7 months, mean % body fat of students across the three time points was within the optimal range for good health [6]. However, it is also important to note that the changes in body composition measures of students were mostly an increase in fat mass and a reduction in skeletal mass. Therefore, weight alone should not be considered the sole indicator of health status of physically active students. Rather, other body composition parameters such as fat mass and skeletal mass also need to be taken into account to determine if the gain in weight reflects a healthy or unhealthy state.

Moreover, despite the average BMI scores for all time points (T1 = 22.72, T2 = 22.63, T3 = 22.98) were considered normal following the international criteria [27], mean BMIs were almost within the overweight category of 23.0 kg/m2 based on Asian and Pacific populations [16, 26]. This implies that despite being physically active, these university students may be susceptible to weight-related health problems if the increasing trend continues and therefore underscores the importance of weight gain prevention.

Weight and body composition changes of male and female students

Studies concerning weight change in male students during the freshman year are scarce. Beaudry et al. [3] found that men significantly gained weight and fat mass and increased BMI and % body fat scores at the end of their study period. Pullman et al. [23] also observed an increase in body weight, BMI, and body fat percentage among freshman men. These previous findings contradict the present result that found no significant changes in weight and other body composition variables after the 7-month study period. These differences may be attributed to the previous sample participants as well as the study length. In the meta-analyses conducted by Vadeboncouer et al. [24] and Vella-Zarb and Elgar [25], study length had a significant impact on participants' weight gain. Nevertheless, the results of the present study revealed that 60% of the total male students gained weight and 58.2% of them were classified as either overweight (30.91%) or obese (25.45%) based on the BMI Asian classification after 7 months in their first year at university [16]. Therefore, interventions that circumvent future undesirable health consequences of weight gain are warranted.

Similarly, changes in weight and other body composition measures of female freshman students were found to be not substantial. The findings conflicted with previous reports that showed that female freshman students had significant changes not only in weight, but also in all body composition parameters [12]. This discrepancy could be owing to the selected participants being limited to first year students of a specific college/major and identified to be considerably active rather than from a broad-range of subjects [8, 17]. As a whole, 54% of the total female students gained weight and 35.48% of them were classified as either overweight (29.03%) or obese (6.45%) based on BMI Asian classification after 7 months in their first year at university [16].

Strengths and limitations

A strength of the study is that the participants' anthropometric and body composition data were measured following strict protocol across all time periods rather than self-reported data from participants [11]. Self-reported data is suggested to be avoided, because participants tend to overestimate and underestimate their height and weight, respectively, leading to inaccurate results [25]. The sample size with a higher proportion of male students is another strength of this investigation, since a majority of previous studies were comprised of either predominantly female or all female participants [3, 8, 15].

For the limitation, the duration of the study was only 7 months and thereby did not cover the complete freshman academic year. However, study duration is comparable [12, 18] or even longer [14, 21] than previous investigations. Secondly, the sample size might be considered small (86). Twenty three students did not complete the three testing periods and thereby were excluded in the study. Nevertheless, a 78% retention rate of the current study was better than other studies and still exceeded the minimum sample size to achieve statistical power. Lastly, participants were all attending the College of Physical Education, thereby limiting the findings to this sample population. Further studies should include physically active freshman students from other colleges to increase the generalizability of the results. Further, we did not assess students' dietary intake or eating behaviors. Determining the type and amount of food students eat and when and why they consume these foods may provide a better understanding of their health behaviors. Negative health behaviors such as excessive alcohol and junk food intake are potential predictors of freshman weight gain [25], and identifying what negative health behaviors students engage in, can be informative when creating nutritional programs that target food items or behaviors associated with weight gain.

Conclusions

This study provides important insights concerning the changes in weight and body composition of specific group of freshmen students, as well as underscores the contribution of the physical activity level in preventing weight gain in first year university students. This result therefore demonstrates an association between physical activity and weight gain in freshman students. Secondly, the findings add further knowledge on weight gain (or its absence) when transitioning to university in a non-western nation, particularly in South Korea, and show how culture may affect incidence of weight gain in freshman students. Third, while average weight gain of students did not significantly increase after 7 months in their freshman year, the increase was smaller compared with that observed in other countries. Finally, the proportion of students in terms of weight and fat mass results was somewhat concerning due to the fact that a majority of them gained weight (58%) and fat mass (71%).

It is therefore suggested that weight gain prevention programs are provided for first-year university students, even to those who are physically active. Preventive strategies and interventions are recommended such as nutrition education focusing on late night eating, skipping breakfast, and high alcohol consumption that can lead to weight gain and other detrimental outcomes to one's health.

Conflict of Interest

The authors declare no conflict of interest.

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UCP2	DD					ID					II				
Sex	*N*	$\bar{x}$	*SD*	*Min*	*Max*	*N*	$\bar{x}$	*SD*	*Min*	*Max*	*N*	$\bar{x}$	*SD*	*Min*	*Max*
F	42	45.65	*6.14*	32.30	59.00	36	45.66	*7.18*	30.60	59.80	7	45.07	*7.60*	35.00	54.80
M	72	54.01[a]	*6.20*	40.30	79.00	70	55.60	*7.32*	42.30	76.80	12	59.07[a]	*9.04*	49.70	74.90

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