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The Effect and Durability of Exercises and Sports Games on the Fundamental Motor Skills of Children with Intellectual Impairment: A Randomized Controlled Trial

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ABSTRACT

Background and Objective: Children with intellectual impairment (II) show poor motor skills due to their low cognitive abilities. Considering the impact of participation in physical activities, the aim of the present study was to investigate the effect and durability of exercises and games on fundamental motor skills (FMS) of II children.

Methods: This randomized controlled study assessed 60 boys with mild II in three groups, exercises (aerobics and resistance), sports games (basketball and futsal), and control (in eight weeks), using the TGMD-2. The prevalence and association between hypomagnesemia and various disease and population variables were determined. The data were analyzed using SPSS at the significance level of $P<0.05$.

Findings: In boys with mild II (mean age=9.80±1.15 years), there were significant differences in the "intergroup" between the intervention and control groups in motor competence, locomotor skills (running, hopping, leaping, jumping and sliding) and object control (throwing and rolling) at post-test ($P=0.001$) and follow-up ($P<0.05$). There were significant differences between all groups in hitting in the post-test and in the follow-up examination ($P<0.05$). In the "intragroup", there were significant differences in all variables in the exercises and games during the pre-test and post-test, the pre-test and follow-up (except the gallop) and the post-test and follow-up ($P=0.001$).

Conclusion: This study revealed the positive effect of the interventions on most of FMS variables, and the sports game group performing better. Due to the modality of the physical activity interventions, the integration of these two types of interventions may show a better effect.

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Introduction

Motor skills are defined as the quality of coordination and performance in the execution of various movements, and fundamental motor skills (FMSs) are considered one of the fundamental and basic aspects of motor skills [1]. FMS forms the basis for new, more advanced and more complex motor skills and is constantly in flux throughout life, usually being learned in pre-puberty [2]. Different forms of physical activity (PA) cause the development of skills during childhood. Basic motor skills are therefore related to children's daily life and are also involved in the acquisition of specific motor skills in sports [3]. FMS is the basic structure required for participation in sport and PA. It should be considered that these skills are not developed naturally but are learned or trained [1].

Childhood is an essential stage for the continuation of human motor development, which interacts during this period of physical, cognitive, and emotional development. Considering this, childhood provides an opportunity for interventions to strengthen its development in all aspects [4]. Improving FMS is believed to promote physical, cognitive and social development, and on the other hand, it is considered the basis of an active lifestyle [2]. On the other hand, children suffering from various impairments may have problems in showing and learning motor skills. One of the groups of impairments whose high prevalence is also reported in the world is intellectual impairment (II). II refers to the in which general intellectual functioning is below average (IQ below 70), limitations in abilities and adaptive skills are evident [5, 6] and symptoms appear before the age of 18 or 22 [7, 8]. II with defects in neural development causes limitations in mental function (intelligence) and adaptive behavior [9] and impairs the affected person in many social and practical skills [10].

Children with II show low cognitive abilities due to problems in processing complex information and learning new skills, and these problems are reflected in poor language, psychosocial and motor skills [11]. Obvious motor deficits in children with II result in FMS children being weaker than normal children [11]. Poor motor function observed in children and adolescents with II is related to impaired mental function [12], and they have been indicated to have poorer FMS than typical peers [13]. In addition to impaired mental function, lack of or limited participation in motor activities also has a negative effect on the function and motor skills of these children [2].

Exercise and sport have been shown to have positive effects on maintaining normal brain activity, especially the positive relationship between exercise and cognitive function [14]. II may affect learning and performing PA; particularly as cognitive delays are likely to affect reaction time, basic motor learning patterns, physical fitness and the development of complex motor skills [15]; however, increased participation in PA provides children with more opportunities to develop FMS [16]. Children with II require special educational services due to their lower mastery of abstract thinking, which cannot be addressed [17]. There is no consensus among researchers on the most appropriate training methods for these people with special needs [18]. On the other hand, children in special schools are taught more daily living skills [18], but no special emphasis is placed on improving physical and motor functions [18]. Sport and health interventions should pay attention to the attitudes and behaviors of children and adolescents with II in order to increase the possibility of participation in sport and PA among these individuals. Therefore, the implementation of appropriate interventions considering the specific characteristics of people with II should be considered essential. In this regard, the present study investigated the effect and durability of a course of exercises and sports games on the FMS of children with II, so that, based on the results, the necessary recommendations can be made for special centers and schools.

Methods

Study design and participants

This randomized, double-blind, controlled study was conducted on boys with mild II and in the age group of 8-12 years in parallel groups.

Sample size and sampling

The number of participants was calculated using the statistical software G*Power with 95%

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confidence and 80% power (version 3.1.9.4; University of Kiel, Germany). Similar to other studies [14, 19], 60 individuals were selected for three groups (two experimental groups and one control groups). Finally, due to the equalization of the number of subjects in the groups and the drop in the number of subjects when the study was conducted at different time points (pre-test, post-test and follow-up), the number of 20 subjects for each group was compared. One intervention group performed exercises and another intervention group performed sports games. Based on a random order (coded boxes with a random order), several qualified special schools in Zanjan were randomly divided into experimental and control groups. The design was such that the interventions began after the Nowruz vacations and the post-test period was evaluated at the same time as the start of the summer vacation. After 3 months and the start of the new school year, the follow-up period was evaluated.

Inclusion criteria included (a) mild II, (b) ability to follow verbal instructions with minimal physical guidance, and (c) no physical disability or other health impairment that might limit physical activity, and (d) no participation in similar exercise programs at the same time as performing the study and no participation in regular physical activity during the follow-up period [10]. In addition to reviewing the students' medical records, a psychologist working with the school was also asked to confirm the subjects' mental impairment status and categorize them as "mild".

Evaluation tools

Exercise and sports game programs

Eight-week exercise and sports game programs (three sessions per week, 50 to 65 minutes per session) were established following other similar studies [19-30], and the opinions of several experts in the field of physiotherapy and sports sciences in Iran were also obtained on the type of exercises before implementation (Tables 1, 2). In addition to the present researchers, several sports science students and sports coaches of people with special needs played a role in conducting the interventions under the supervision of the main researcher.

The interventions were carried out in two groups of exercises by performing aerobic exercises and resistance exercises focusing on core exercises, and in the other group, basketball and futsal games and performing their skills. The interventions were conducted for eight weeks, 3 sessions per week, and each session lasted between 50 and 65 minutes while the children attended school.

Table 1. Overview of the exercise program

Type of Exercise		Program
Warm-up	Type	Running and stretching exercises
	Time	10 minutes
	Intensity	9-14 RPE*
Aerobic Exercises	Type	Rhythmic exercises with music (basic aerobics exercises), interval sprints
	Time	25 minutes
	Rest	5 minutes
	Intensity	8 – 15 RM**
Resistance Exercises	Type	Crunch, reverse flyes, biceps curl, lateral raises, chest press, squats, tensing the abdominal muscles while lying in a supine position, tensing the abdominal muscles in supine position with one leg extended and the other bent at the knee and pressed against the abdomen, lifting the opposite arm and leg during squats
	Time	20 minutes
Cool Down	Type	Stretching exercises
	Time	5 minutes

* rating of perceived exertion

** maximum repetition

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Table 2. Overview of the sports game program

Type of Exercise		Program
General Warm-Up	Type	Running and stretching exercises
	Time	5 minutes
Specific Warm-Up	Type	Reviewing previous exercises and working with the ball
	Time	5 minutes
Futsal Training	Type	Controlling the ball, passing the ball, carrying the ball, dribbling, and shooting the ball toward the goal
	Time	20 minutes
	Rest	5 minutes
Basketball Training	Type	Carrying the ball, catching the ball, passing the ball, dribbling, changing direction with the ball and shooting toward the basket
	Time	20 minutes
Cool Down	Type	Stretching exercises
	Time	5 minutes

Fundamental Motor Skills (FMS)

The FMS was evaluated using the Test of Gross Motor Development - second edition (Ulrich) (TGMD-2) [2, 3, 10, 11, 31-33]. This test was used to assess the quality of motor development [1, 14]. The TGMD consisted of 12 FMS (six locomotor skills and six object control skills) and took approximately 20 minutes to complete. Locomotor skills subtests included running, galloping, hopping, leaping, jumping and sliding. Object control subtests included hitting a stationary ball, dribbling at rest, catching, kicking, overhand throw and underhand roll. The TGMD-2 is an assessment tool that is considered the gold standard for FMS assessments [1].

TGMD-2 was a qualitative assessment in which each skill was scored against performance criteria according to the manual (3-5 criteria for each skill). The scores of the locomotor skills and object control subtests were summed to calculate the total score for locomotor skills and object control (each score ranges from 0 to 48), and finally the total scores for locomotor and object control skills were added for the sum of the FMS (actual motor skill). After a visual presentation of each skill, the subject was asked to perform the skill twice. In addition, subjects were allowed to complete a practice session in the pre-test phase one day before the test to ensure that they understood the motor task [10]. During the test, the entire procedure was recorded with a video camera (HDR-CX450, SONY, Japan) to avoid errors in scoring. It has been reported that the TGMD-2 test is one of the most powerful instruments for evaluating the motor characteristics of children with II [34].

Statistical analysis

Descriptive statistics were used to describe the data of each group (age, height, weight and body mass index of the subjects); Shapiro-Wilk test was applied to determine the normal distribution or lack of normal distribution of the data; and inferential statistics (one-way ANOVA, repeated measures, Bonferroni and T-tests) were used to compare the variables of the research. The significance level in the current study was $p<0.05$, and all statistical analyses were performed using SPSS 25 (IBM Corp., published 2010; Armonk, New York, USA).

Results

The method of selection and allocation of subjects to the intervention and control groups in the research process and the number of subjects in each period are shown in Figure 1.

The results of the ANOVA test indicated that the individual information of the subjects was homogeneously distributed in two groups (Table 3).

In the inter-group comparisons, there were significant differences between the intervention and control groups in actual motor competence, locomotor skills (running, hopping, jumping, skipping, sliding) and object control (throwing and rolling) at post-test and follow-up (Table 4).

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There were significant differences between all groups in hitting in the post-test and the follow-up examination. For dribbling and kicking, there were significant differences between the intervention and control groups in the post-test and between the sports game and control groups in the follow-up (Table 4).

For catching, there were significant differences between the intervention and control groups in the post-test and between the exercise and sports game groups as well as between the sports game and control groups in the follow-up (Table 4). In intra-group comparisons, all variables were significantly different in the exercise and sports game groups during the pre-test compared to the post-test, the pre-test compared to the follow-up (except gallop) and the post-test compared to the follow-up (Table 4).

Fig 1. CONSORT flowchart of study

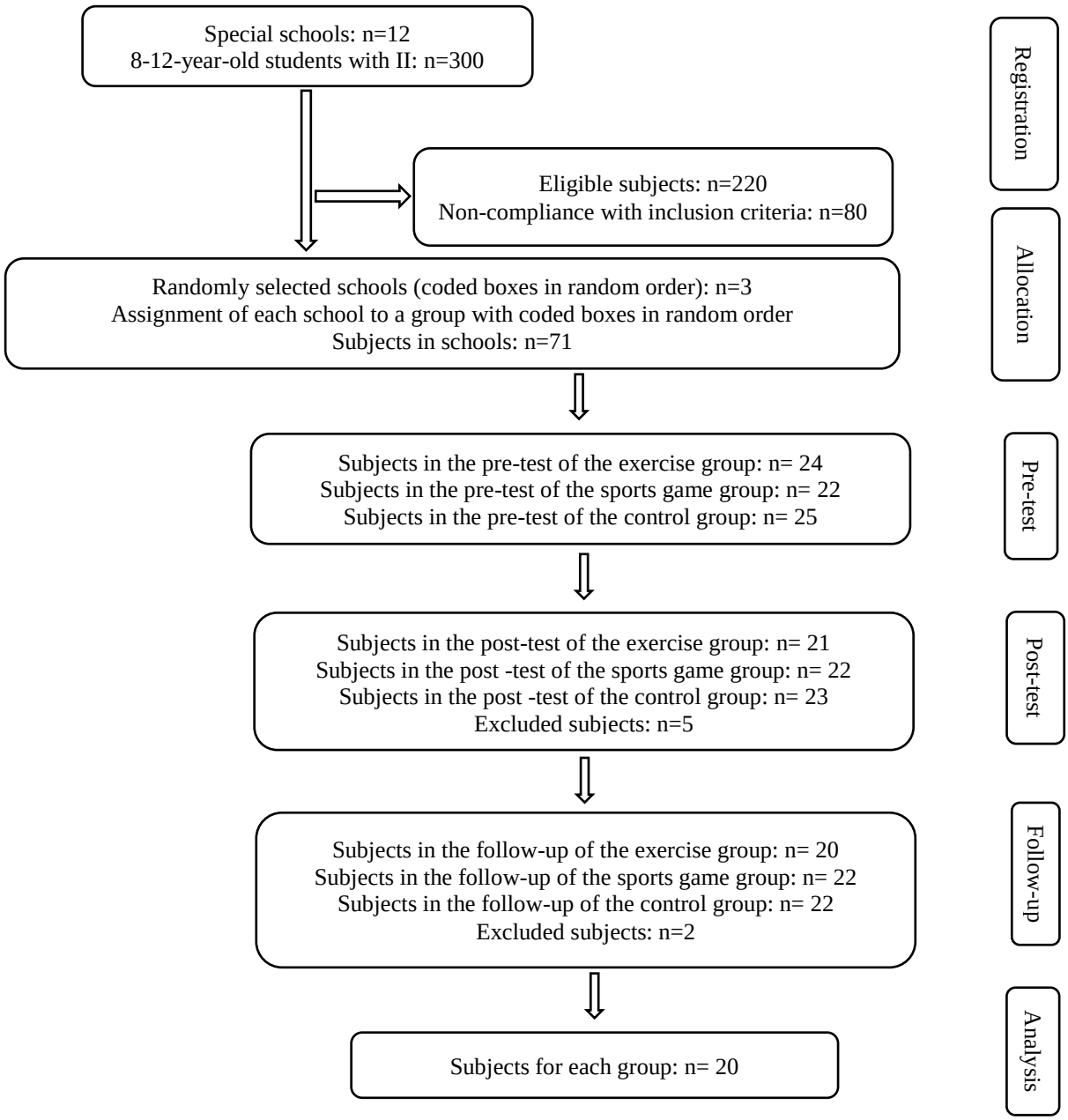

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Table 3. Individual information of the test subjects (mean ± standard deviation)

Variable	Exercises Group	Sports Game Group	Control Group	P-Value
	Mean ± SD	Mean ± SD	Mean ± SD	
Age (years)	9.90±1.16	9.80±1.15	9.70±1.08	0.856
Height (meters)	1.34±0.01	1.34±0.03	1.34±0.02	0.824
Weight (kg)	35.05±1.50	35.20±2.39	35.25±1.91	0.946
BMI (kg/m^2)	19.33±0.54	19.41±0.52	19.58±0.46	0.288

SD=standard deviation

Table 4. Summary of Bonferroni test results for intragroup and intergroup comparison of FMS

Variable	Group	Intragroup comparison			Intergroup comparison			
		pre v post	pre v fol	post v fol		pre-test	post-test	follow-up
actual motor competence	Exercises	0.001*	0.001*	0.001*	exe v spo	1.000	1.000	0.817
	Sports games	0.001*	0.001*	0.001*	exe v con	1.000	0.001*	0.050*
	control	0.502	0.068	0.002*	spo v con	1.000	0.001*	0.002*
Locomotor Skills	Exercises	0.001*	0.001*	0.001*	exe v spo	0.903	1.000	1.000
	Sports games	0.001*	0.001*	0.001*	exe v con	0.533	0.001*	0.025*
	control	1.000	0.020*	0.013*	spo v con	0.765	0.001*	0.035*
Object Control skills	Exercises	0.001*	0.001*	0.001*	exe v spo	0.776	0.110	0.083
	Sports games	0.001*	0.001*	0.001*	exe v con	1.000	0.001*	0.026*
	control	0.060	0.004*	0.796	spo v con	0.550	0.001*	0.001*

pre v post = pre-test with post-test; pre v fol = pre-test with follow-up; post v fol = post-test with follow-up
exe v spo = exercises with sports games; exe v con = exercises with control; spo v con = sports games with control
***A significance level was considered p<0.05.**

Discussion

The present study suggested that after eight weeks of exercises and sports games, not only did the function of FMS improve, but also over time and at follow-up, a state of recovery was still observed compared to before the interventions were carried out. Therefore, implementing targeted interventions and taking into account the conditions, characteristics, and special instructions of people with II can lead to positive changes in these abilities.

In terms of motor skills, the sports game group recorded better results after the interventions. This also applies to all object control variables. The type of movements performed during the sports games, especially the exercises for catching, passing, throwing and shooting the ball, and so on was able to specifically improve the function of object control skills in children with II to such an extent that even the function with other intervention methods was better. The evaluation of the follow-up study also indicated that the sports game group maintained their positive effects on all variables of the FMS with the exception of galloping.

For variables of locomotor skills, the group of movement exercises showed a better function than the sports game group. The presence of rhythmic and aerobic exercises together with muscle-strengthening exercises could strengthen some skills such as running, leaping, hopping and sliding. However, the sports game group performed better in horizontal jumping. The displacement movements

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performed during the futsal and basketball exercises, especially when dribbling and carrying the ball, seem to be able to show their desired effect, although these comparisons were not observed statistically; this can be determined from the average values. Therefore, it can be concluded that sports games in combination with some motor exercises can have visible effects on the condition of the FMS.

Unfortunately, no study comparing different exercise models in terms of their effects on FMS was observed by the current researchers. However, there have been studies comparing FMS in children and adolescents with II. Kakejani et al. (2024) investigated the effect of game-based exercises on FMS in children with Down syndrome. FMS scores improved, but there was no significant improvement in active memory scores [14]. Moreover, Zourmand et al. in 2024 found that implementing a game-based program in schools effectively improves the motor skills of children with autism spectrum disorders and emphasized the importance of programs highlighting proper exercise and sports to support their physical, cognitive and social development [4]. Özkan and Kale (2023) also stated after their review that special schools' sports activities improve motor skills and quality of life [35]. The findings of the current study are also consistent with the mentioned studies, but the evaluation methods are different in some studies. Another point is that these studies did not focus on a specific method of exercises or games.

Motor defects often manifest themselves in a lack of control of the FMS [11, 13]. Children with II show low cognitive abilities due to problems in processing complex information and learning new skills, which are reflected in impairments in language, psychosocial and motor skills [11]. Such conditions cause many changes in their development path and also pose many challenges to the families who care for them [36]. The delay in the development of physical fitness and motor skills of children and adolescents with II can lead to a delay in functional development, resulting in motor activities becoming boring for them in later stages of life and the ability to play sports, control and coordinate objects decreasing more and more [37]. It seems that the continuation of such conditions will cause them severe problems in their daily activities, physical and social activities, and so on in later stages of life.

Children with II usually also show signs of impaired or delayed development of motor skills [33]. It has been shown that poor motor function in these individuals is related to impaired mental function [12]. In addition to impaired mental function, the lack of or limited participation in motor activities observed in children and adolescents with II also negatively affects children's motor skill function and performance [2]; for this reason, coaches should always try to maintain the participation of these students and increase their learning time [38].

The presence of neurological disorders interferes with the display of motor function and due to changes in the brain (such as cell complexes and phase-sequences), neurophysiological adaptations to exercise which can lead to an increase in neurotransmitters and an improvement in the diameter of motor-related neurons, which required more time to adapt, and thus motor function can be improved. People with II who suffer from these neurological disorders can interact more with the environment through exercise [14]. The exercise process as an uninterrupted period parallel to developmental growth affects not only the motor aspects but also cognitive and emotional-social processes [39], and the positive cognitive changes it induces lead to increased participation in sports [40, 41]. Childhood is considered a fundamental stage for human motor development. Therefore, it is necessary to investigate interventions that promote motor skills during this period, especially in children with II [4].

Activities based on children's interests provide opportunities for experiences that are important for development. It has been reported that not only does it enhance children's cognitive development, but also working memory and information processing speed can be predicted by gross motor development [1]. On the other hand, the game provides a pleasant and attractive environment and thus facilitates the acquisition and improvement of necessary motor skills [42]. According to the results of the present study, it can be said that the sports games performed

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in a calm environment and without coercion and which meet the needs and abilities of children with II, were better able to improve FMS better. It was found that motor-based games stimulate intelligence, counteract a sedentary lifestyle, improve psychomotor skills, increase safety and can also be an interesting form of active recreation [43].

Improved FMS function in children is not only a positive predictor of participation in PA and sports, but is also positively related to cognitive, social and emotional development and health-related physical fitness [10]. Through game-based activities, children not only get to know their bodies and physical abilities better but also develop cognitive and emotional issues [4]. Game plays an essential role in students' motor skills. Through play, their physical, motor, social, emotional and cognitive aspects are optimally developed [19]. Participation in sport can develop teamwork skills and the ability to communicate effectively with other members of society in people with and without impairments [44]. Games are PA to have fun and are usually performed in a group. Games can develop the skills and abilities of people with special needs or children with impairments [19].

Zourmand et al. (2024) reported that games performed in special schools are effective in promoting the development of motor skills in children with autism spectrum disorder [4]. The results of the present study are also consistent with their findings. However, unfortunately, in the special schools where this study was carried out, there are few PAs because there is no physical education teacher. According to these findings, the presence of sports coaches with sufficient knowledge of the needs of people, especially children with II, is important in these schools. Even if the results of the follow-up are analyzed, it can be seen that the motor status of these children in different school years can improve compared to the previous years if the conditions of recovery (compared to the period before the implementation of the interventions) are maintained. In this regard, Zhang et al. (2021) have pointed out in their study that the FMS performance of children with severe II can also be significantly improved by one-year PA interventions [10]. Considering the degree of mild II in the present study, this problem is also possible. In general, children with II show a delay in motor development. Corresponding to the impairment of sensorimotor function, delays in motor development, deficits in motor control, deficits in motor sequencing and low concentration scores can also be observed in them. In addition to the locomotor system, object control and balance skills are also affected, depending on role, daily activities, sports, PA and leisure activities [1]. Based on the positive effects observed both at post-test and follow-up, it can be concluded that the implementation of sports interventions can improve the motor skills of children with mild II.

Despite the valuable contribution that the current study makes to researchers, there are limitations such as the small sample size due to the evaluation in one province as well as the challenges related to the evaluation of the FMS. There were not enough female subjects, which limited the results to males, and there was also no control for subjects' PA levels out of school or during school closures until follow-up.

Conclusion

According to the results of the present study, it can be concluded that the implementation of targeted interventions oriented to the conditions, characteristics and instructions of people with II, and also taking into account the FMS, which are the basis for learning and performing motor skills in the future, the integration of such cases can improve motor assistance.

Acknowledgments

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Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Sport Sciences Research Institute (Code: IR.SSRC.REC.1402.023) and registered

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with the Iranian Registry of Clinical Trials (IRCT) (Code: IRCT20230407057840N1).

Authors' Contributions

All authors contributed equally to the preparation of all parts of the study.

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Conflicts of Interest

The authors have declared no conflicts of interest.

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