

Effect of an 8-Week cross-country skiing program on physical fitness levels in children aged 8–12 years

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Abstract:

Purpose: This study aimed to investigate the effects of an 8-week cross-country skiing program on the physical fitness of children aged 8–12 years. **Methods:** Forty-five male children with a mean age of 11.3 ± 0.13 years voluntarily participated and were assigned into three groups: cross-country skiing group (CCSG, $n = 15$), walking group (WG, $n = 15$), or control group (CG, $n = 15$). The exercise intervention consisted of 30 min training sessions performed three times per week for 8 weeks. Training intensity and distance were progressively increased by 2.5% each week. Participants' height, bodyweight, body mass index (BMI), body fat percentage (BFP) and fat-free mass (FFM) were measured. Motoric characteristics were assessed by flexibility, standing long jump, right-hand and left-hand grip strength, pull-up hang duration, static balance, T-agility test, 20 m shuttle run and 30 m sprint tests, applied in both pre-test and post-test formats. The data were analyzed using SPSS 23.0 software. **Results:** There were significant differences among the CCS, W, and C groups in bodyweight, right-hand and left-hand grip strength, and pull-up hang duration; between the CCS and C groups in static balance, standing long jump, BFP, and BMI; and between the CCS and W groups in maximal oxygen consumption (VO_{2max}). However, no significant differences were found among the groups in terms sprint speed, agility, flexibility, FFM, or height ($p < 0.05$). **Conclusion:** The cross-country skiing program implemented over 8 weeks showed improvements in physical, physiological, and motor parameters in children aged 8–12 years. Additionally, the walking group also showed notable increases in these parameters compared to the control group at the end of the 8-week program.

Keywords: Winter sport, motor skills, aerobic fitness, walking, adolescent

Introduction

Sport and physical activity provide numerous benefits for children and adolescents, including psychosocial, cognitive, and musculoskeletal development, a reduced risk of being overweight, and an improved quality of life (Contreras-Osorio et al., 2021). Sport is one of the most popular recreational activities worldwide, and in many countries, most children and adolescents participate in sports and related activities (Aubert et al., 2018). One of the most influential periods during which sports participation affects human development is childhood. Engaging in physical activity and sports during childhood and adolescence positively affect various psychological and social developmental aspects, such as mastering fundamental movement skills, coping with physically demanding tasks, deriving enjoyment from the activity, and fostering both participation in and motivation toward sports (Akıncı & Ateş, 2023).

Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure, which is a feature of sports activities (Rejeki et al., 2021). Physical fitness, on the other hand, is defined as the ability to perform physical tasks successfully and without difficulty (Güler, 2023). Regular physical movement, whether of low or high intensity, supports a healthy lifestyle by increasing calorie expenditure (Sugiharto et al., 2022). Therefore, participation in physical activity is particularly important for the development and wellbeing of primary school children (Basuki et al., 2021). Children who engage in daily physical activity can maintain their physical appearance and conditioning, whereas individuals who adopt a sedentary lifestyle with limited regular activity tend to have increased body fat percentage (BFP) and a decline in their overall physical condition (Fonseca et al., 2018). In recent years, a general decline in the physical fitness levels of children and adolescents has been reported worldwide. Consequently, an increase in health problems related to physical fitness, such as obesity, has also been observed. The decline in physical fitness and the rising prevalence of childhood obesity has become a significant global concern due to their long-term health implications. This situation requires the development of effective intervention strategies among children and adolescents. In this context, implementing after school physical activity-based exercise programs provides opportunities to improve both health outcomes and physical fitness (Kretschmann, 2023). Enhancing physical fitness requires regular participation in various physical activities and regular exercise and physical activities are essential for this, as they contribute to improvements in children's maximal oxygen consumption (VO_{2max}), body

consumption, muscular strength, endurance, and flexibility (Adi et al., 2022). Participation in physical activity is associated with higher physical fitness levels and improved maintenance of physical appearance in children, compared to their sedentary peer (Munoz-Vera et al., 2017). Children with underdeveloped motor skills tend to avoid physical challenges they encounter in daily life, which can lead them toward a sedentary lifestyle. To prevent health problems associated with physical inactivity and to improve health status and quality of life in adulthood, it is crucial to instill regular physical activity habits during childhood. Among the most recommended activities to combat a sedentary lifestyle are walking, running, swimming, cycling, dancing, and skiing (Özcan, 2018). Since opportunities for outdoor physical activity decrease during the winter months, promoting winter sports, such as cross-country skiing, are essential for both protecting the health of children and adolescents and motivating them to be physically active (Babaei-Zarch et al., 2024).

Cross-country skiing is a complex performance sport that requires all fundamental physical attributes, including endurance, balance, strength, flexibility, and coordination (Çetin & Yarım, 2006). This Olympic winter sport based on walking, is performed outdoors in various terrain and weather conditions, and can be easily practiced by individuals of all ages. Cross-country skiing is divided into two main techniques: classical and skating. Athletes compete in both short and long distances events, ranging from 1.5 km to 50 km (Seeberg et al., 2022; Hinder et al., 2024). Therefore, in addition to being a highly competitive winter sport, cross-country skiing has become an important physical education activity and form of exercise for children and adolescents (Eshiev et al., 2025). During the winter months when physical inactivity is less prevalent, cross-country skiing serves as a highly valuable form of physical activity and exercise for children, adolescents, and adults. Individuals tend to participate less in physical activity and exhibit lower daily energy expenditure in winter compared with summer. Physical inactivity is a primary cause of cardiovascular disease. Thus, it is essential to identify physical activity and exercise strategies aimed at maintaining or even improving physical health during the winter season (Stöggl et al., 2016). Research has shown that individuals who begin participating in sports from an early age have better physical fitness compared with their peers. Therefore, engaging in any form of physical activity and sport plays a key role in improving individuals' physical fitness levels (Çağın et al., 2024). Studies conducted within this age group have shown improvements in the physical, physiological, and motor characteristics of children who regularly participate in physical activity. Kretschmann (2023) reported that in middle school students, an 8-week resistance training program led to significant improvements in performance parameters, such as push-ups, sit-ups, flexibility, and jumping. Akıncı and Ateş (2023) found that participation in school-based physical activity programs increased physical fitness levels compared with students who did not engage in any physical activity. Similarly, Ma'arif et al. (2023) identified a significant and positive relationship between physical activity and physical fitness. In line with these scientific findings, the World Health Organization (WHO, 2020) recommends that children engage in an average of 60 min of moderate to vigorous physical activity per day, at least 3 days per week, and additionally incorporate muscle-strengthening exercises. Although the physiological and psychological benefits of cross-country skiing are well recognized, its effects on the health and physical activity levels of children and adolescents remain unknown.

We hypothesize that an 8-week cross-country skiing exercise program will significantly improve the physical fitness levels of children aged 8–12 compared with a walking group and a control group. Additionally, generating reference data for this age group is expected to contribute to future comparisons and talent identification processes. As such, the aim of this study was to examine the effect of an 8-week cross-country skiing program implemented as an alternative physical activity during the winter months on physical fitness and performance development in children aged 8–12 years.

Materials and methods

Study participants

45 male students aged 8–12 years with a mean age of 11.3 ± 0.13 years, voluntarily participated in the study. All students had no major health issues within the last 6 months and were not on any regular medication. Informed consent forms were obtained from both the students and their parents prior to the testing and exercise sessions. Participants were randomly assigned into three groups ($n = 15$ each): the cross-country skiing (CCS) group who engaged in cross-country skiing exercises, the walking (W) group who performed walking exercises, and the control (C) group who did not participate in any structured exercise program. Only students with no health restrictions for participation in physical education and sports classes were included in the C group assessments.

Study organization

The pedagogical experiment was conducted for 8 weeks, with participants in the CCS and W groups following structured exercise programs three times a week for 30 min per session, performed every other day. The CCS group followed a classical technique cross-country skiing program, while the W group performed normal walking exercises. The intensity and distance of both programs were increased weekly by 2.5% to ensure a progressive training load. All measurements were conducted before (pre-test) and after (post-test) the intervention. Data collection involved the EUROFIT Test Battery, designed by the Council of Europe, for assessing physical fitness in school-aged children. Prior to testing, all procedures were explained in detail to the students, and demonstrations were performed for each test to ensure accurate execution.

Measures and instruments

Height was measured using a Holtain stadiometer with a precision of 0.01 m. Measurements were taken with participants barefoot, standing upright, with their arms at the sides, and heels against the stadiometer. Values were recorded in cm. Bodyweight, body mass index (BMI), BFP, FFM, and fat mass were assessed using a TANITA BC – 418 body composition analyzers. Measurements were taken without socks and 0.5 kg was subtracted to account for clothing. Age and height were also entered into the device.

Flexibility was assessed using the sit-and-reach test. Participants sat with legs extended and feet flat against the test box, reaching forward along the measurement scale. The farthest point reached was recorded in cm. Two trials were performed, and the best result was recorded (Kürkçü et al., 2009).

For the standing long-jump test, participants bent their knees and used their arms to propel themselves forward, attempting to jump as far as possible from the takeoff line. Two trials were performed, and the best result was recorded (Kamar, 2003). The handgrip strength test was conducted using a Holtain hand dynamometer. Participants squeezed the device with maximum effort while in the anatomical standing position. Two trials were performed for each hand, and the best value was recorded.

For the upper body strength test, participants were assisted into a position where their chin was above the bar level and were asked to maintain this position for as long as possible. The duration was recorded using a stopwatch. The balance test involved having participants stand on a wooden balance beam using their dominant foot. They bent the non-dominant leg, pulling it toward the hip and holding it with the same-side hand, attempting to maintain balance for as long as possible. Two trials were conducted, and the best duration was recorded. For the agility test, participants moved between four cones following a specific pattern of running and side-stepping. The best time was determined using a photocell system after two trials (Bayraktar, 2013).

For the 20 m shuttle run test, participants ran back and forth for 20 m synchronized with audio signals. The pace increased every 10 sec, and the test was terminated when a participant failed to reach the line in time for two consecutive signals. The 30 m sprint test was measured using photocells. Participants sprinted the 30 m distance at maximum speed, and the best result from two trials was recorded (Kürkçü et al., 2009).

Table 1. 8-week cross-country skiing exercise program

Day	Warm-up	Main training	Cooldown
1	10 min jogging	30 min cross-country skiing	10 min stretching
2	10 min jogging	30 min cross-country skiing	10 min stretching
3	10 min jogging	30 min cross-country skiing	10 min stretching

Note: The training program was implemented 3 days a week for 8 weeks using the classical cross-country skiing technique. The intensity of the exercises increased progressively by 2.5% each week.

Statistical analysis

Data were analyzed using SPSS 23.0 statistical software. The Kolmogorov–Smirnov and Shapiro–Wilk tests were used to assess the normality of data distribution. Since the sample size in each group was fewer than 30 participants, non-parametric tests were applied. The Wilcoxon Signed–Rank test was used to identify differences between pre-test and post-test scores within each group. The Kruskal–Wallis test was performed to compare differences across the three groups. The statistical significance was set at $p < 0.05$ for all analyses.

Results

The analyses of pre-test and post-test measurements obtained from the CCS, W, and C groups over the 8-week exercise period are presented in table 2.

Table 2. Comparison of height, bodyweight, BMI, BFP, and LBM values

Parameter	Group (n=15)	Pre-test	Post-test	Within group	Between group	
		Mean $\pm$ SD	Mean $\pm$ SD	p value	p value	Differences
Height (cm)	CCS	140 $\pm$ 2.16	141.4 $\pm$ 2.23	0.03*	0.41	-
	W	152 $\pm$ 1.29	152 $\pm$ 1.26	0.05		
	C	151 $\pm$ 1.88	151 $\pm$ 1.92	0.16		
Bodyweight (kg)	CCS	34.3 $\pm$ 1.91	35.6 $\pm$ 2.26	0.17	0.00*	CCS–C W–C
	W	41.3 $\pm$ 1.88	41.3 $\pm$ 1.9	0.75		
	C	46.1 $\pm$ 3.80	47.6 $\pm$ 3.91	0.00*		
BMI (kg/m ²)	CCS	17.4 $\pm$ 0.59	17.0 $\pm$ 0.59	0.08	0.01*	CCS–C
	W	17.9 $\pm$ 0.60	17.8 $\pm$ 0.62	0.84		
	C	19.8 $\pm$ 1.32	20.2 $\pm$ 1.28	0.02*		
BFP (%)	CCS	16.8 $\pm$ 0.96	15.8 $\pm$ 0.66	0.06	0.03*	CCS–C C–W
	W	19.1 $\pm$ 1.07	18.6 $\pm$ 1.07	0.21		
	C	23.6 $\pm$ 2.21	24.2 $\pm$ 1.89	0.00*		
LBM (kg)	CCS	30.9 $\pm$ 2.85	31.3 $\pm$ 2.49	0.08	0.55	-
	W	33.3 $\pm$ 1.22	33.8 $\pm$ 1.23	0.11		
	C	32.6 $\pm$ 2.6	35.2 $\pm$ 2.16	0.01*		

BFP=body fat percentage. BMI=body mass index. C=control. CCS=cross-country skiing. LBM=lean body mass. SD=standard deviation. W=walking. * $p < 0.05$, statistically significant.

Table 2 shows a significant difference at the 95% confidence interval in the C group for bodyweight ($p = 0.00$), BMI ($p = 0.02$), BFP ($p = 0.00$), and LBM ($p = 0.01$), and in the CCS group for height ($p = 0.03$) after exercise ($p < 0.05$). However, no significant difference was found in the pre-test and post-test values of bodyweight, BMI, BFP, and LBM in the C and W groups after exercise ($p > 0.05$). Analysis of between-group differences revealed a significant difference in bodyweight of the CCS versus C groups and between the W versus C groups ($p = 0.00$), in BMI between the CCS versus C groups ($p = 0.01$), and in BFP between the CCS versus C groups and between the C versus W groups ($p = 0.03$), with all of which were significant ($p < 0.05$). When examining between-group differences, no significant differences were observed for height ($p = 0.41$) or lean body mass (LBM; $p = 0.55$).

Table 3. Comparison of right-hand and left-hand grip strength and pull-up hang times

Parameter	Group (n=15)	Pre-test	Post-test	Within group	Between group	
		Mean $\pm$ SD	Mean $\pm$ SD	p value	p value	Differences
Right-hand grip strength (kg)	CCS	19.5 $\pm$ 1.63	22.4 $\pm$ 2.19	0.01*	0.01*	CCS-W CCS-C
	W	23.3 $\pm$ 1.32	22.5 $\pm$ 1.15	0.00*		
	C	19.4 $\pm$ 1.28	19.5 $\pm$ 1.02	0.93		
Left-hand grip strength (kg)	CCS	19.5 $\pm$ 1.89	21.9 $\pm$ 1.90	0.01*	0.01*	CCS-W CCS-C
	W	21.6 $\pm$ 1.07	21 $\pm$ 1.19	0.14		
	C	18.6 $\pm$ 1.01	19.1 $\pm$ 0.86	0.24		
Pull-up hang time (sec)	CCS	22.2 $\pm$ 2.44	33.6 $\pm$ 3.85	0.01*	0.02*	CCS-W C-W
	W	11.4 $\pm$ 1.66	13 $\pm$ 1.44	0.37		
	C	13.4 $\pm$ 3.16	19.1 $\pm$ 0.86	0.03*		

C=control. CCS=cross-country skiing. SD=standard deviation. W=walking. * $p < 0.05$, statistically significant.

Table 3 shows that post-exercise, there was a significant difference in right-hand grip strength in the CCS ($p = 0.01$) and W ($p = 0.00$) groups, in left-hand grip strength in the CCS group ($p = 0.01$), and in pull-up hang duration in the CCS ($p = 0.01$) and C ($p = 0.03$) groups. However, no significant difference was found in the C group for right-hand grip strength ($p = 0.93$), in the W ($p = 0.14$) and C ($p = 0.24$) groups for left-hand grip strength; and in the W group ($p = 0.37$) for pull-up hang duration between the pre-test and post-test measurements following the exercise intervention ($p > 0.05$). Based on the analysis of between-group differences, significant differences were seen in right-hand grip strength between the CCS versus C and CCS versus W groups ($p = 0.01$), in left-hand grip strength between the CCS versus C and CCS versus W groups ($p = 0.01$), and in pull-up hang duration between the CCS versus W and C versus W groups ($p = 0.02$).

Table 4. Comparison of speed and agility

Parameter	Group (n=15)	Pre-test	Post-test	Within group	Between group	
		Mean $\pm$ SD	Mean $\pm$ SD	p value	p value	Differences
Speed (sec)	CCS	5.15 $\pm$ 0.11	5.02 $\pm$ 0.08	0.12	0.09	-
	W	5.64 $\pm$ 0.07	5.36 $\pm$ 0.08	0.00*		
	C	6.21 $\pm$ 0.18	6.05 $\pm$ 0.19	0.06		
Agility (sec)	CCS	13.2 $\pm$ 0.29	12.6 $\pm$ 11.8	0.12	0.00*	CCS-W
	W	15.2 $\pm$ 0.45	13.4 $\pm$ 0.36	0.00*		
	C	16.5 $\pm$ 0.44	16.1 $\pm$ 0.51	0.06		

C=control. CCS=cross-country skiing. SD=standard deviation. W=walking. * $p < 0.05$, statistically significant.

Table 4 compared the post-exercise speed and agility of the CCS, W, and C groups and showed a significant difference in the W group for both speed ($p = 0.00$) and agility ($p = 0.00$). However, no significant difference was found between the pre-test and post-test speed and agility values in the CCS and C groups following the exercise intervention ($p > 0.05$). Analysis of between-group differences revealed no significant difference among the groups in terms of speed ($p = 0.09$). However, for agility, there were significant differences between the CCS versus W groups ($p = 0.00$).

Table 5: Comparison of VO_{2max}, static balance, standing long jump, and flexibility

Parameter	Group (n=15)	Pre-test	Post-test	Within group	Between group	
		Mean $\pm$ SD	Mean $\pm$ SD	p value	p value	Differences
VO _{2max} (ml/kg/dk)	CCS	40.1 $\pm$ 2.5	43.5 $\pm$ 2.03	0.01*	0.23	-
	W	28.5 $\pm$ 1.24	30.8 $\pm$ 1.3	0.01*		
	C	25.8 $\pm$ 1.1	26.1 $\pm$ 1.25	0.58		
Static balance (sec)	CCS	8.75 $\pm$ 3.55	15.0 $\pm$ 2.99	0.03*	0.01*	CCS-W CCS-C
	W	7.13 $\pm$ 1.86	7.98 $\pm$ 1.92	0.05		
	C	9.69 $\pm$ 4.42	9.07 $\pm$ 4.15	0.4*		
Standing long jump (cm)	CCS	155 $\pm$ 4.36	168 $\pm$ 5.66	0.01*	0.00*	CCS-C
	W	124 $\pm$ 4.66	128 $\pm$ 3.51	0.07		
	C	120 $\pm$ 4.01	118 $\pm$ 4.17	0.28		
Flexibility (cm)	CCS	26.2 $\pm$ 1.43	27.4 $\pm$ 1.04	1.17	0.35	-
	W	17.4 $\pm$ 1.77	19.1 $\pm$ 1.84	0.05		
	C	16.3 $\pm$ 1.49	16 $\pm$ 1.32	0.78		

C=control. CCS=cross-country skiing. SD=standard deviation. VO_{2max}=maximal oxygen consumption. W=walking. * $p < 0.05$, statistically significant.

Table 5 compared the post-exercise $VO_{2\max}$, static balance, standing long jump, and flexibility for CCS, W, and C groups and showed significant differences in $VO_{2\max}$ for the CCS ($p = 0.01$) and W ($p = 0.01$) groups, in static balance for the CCS ($p = 0.03$) and C ($p = 0.04$) groups, and in standing long jump performance for the CCS group ($p = 0.01$). However, no significant differences were found between pre-test and post-test values in $VO_{2\max}$ for the C group ($p = 0.58$), in static balance for the W group ($p = 0.05$), in standing long jump for the W ($p = 0.07$) and C ($p = 0.28$) groups, and in flexibility for all groups ($p > 0.05$). When analyzing the analysis of between-group differences, significant differences were observed in static balance values between the CCS versus W and CCS versus C groups ($p = 0.01$), and in standing long jump performance between the CCS versus C groups ($p = 0.00$). However, no significant differences were observed among the groups in terms of $VO_{2\max}$ and flexibility ($p > 0.05$).

Discussion

The pre-test and post-test values of height, body weight, body mass index (BMI), body fat percentage, and lean body mass of the children who participated in the cross-country skiing exercise are presented in Table 2. When examining studies conducted with children in the same age group in the literature, similar findings have been reported. For instance, in a study conducted by Güneş et al (2019), the effects of an 8-week basic skiing training program on height and body weight were investigated. The pre-test mean values for male participants were 133.38 cm for height and 29.02 kg for body weight. In the post-test results, the average height of the boys increased to 133.69 cm, while their body weight decreased to 27.04 kg. For female participants, the pre-test measurements showed an average height of 134.88 cm and a body weight of 27.44 kg. Post-test values indicated an increase in height to 135.25 cm, and a decrease in body weight to 25.95 kg. Regular physical activity, particularly full-body exercises such as skiing, may enhance the secretion of growth hormones. Additionally, the development of muscles that support an upright posture can lead to improvements in postural alignment, which may positively influence height measurements. İbiş et al (2004) reported that students aged 12–14 who participated in a summer football school showed positive improvements in both height (0.51%) and body weight (1.57%). The study concluded that students who engaged in regular physical activity experienced greater improvements in these parameters compared to those who did not participate in such activities.

Hamamioğlu and Çakmakçı (2010) investigated the effects of basic basketball training on boys aged 9–14. In their study, the height of the experimental group increased from 138.25 cm to 141.30 cm, and the average body weight rose from 40.30 ± 17.34 kg to 41.75 ± 17.68 kg. In the control group, body weight also increased slightly, from 39.25 ± 12.97 kg to 39.90 ± 12.66 kg. Özcan (2018) examined the effects of a 12-week nordic walking (pole walking) exercise program on children aged 10–12. The study found that the body fat percentage of the nordic walking group decreased from $23.2 \pm 0.96\%$ in the pre-test to $21.7 \pm 0.86\%$ in the post-test. Similarly, the walking group showed a decrease from $21.8 \pm 0.88\%$ to $21.3 \pm 0.84\%$. Additionally, during this 12-week period, both groups experienced positive changes in height, body weight, body mass index (BMI), and lean body mass (LBM). In a separate study conducted by Yörükoğlu and Koz (2007), basketball training programs applied five days per week versus two days per week were evaluated in children aged 10–13. The findings indicated that training frequency had no significant effect on BMI or BFP in this age group. The findings of our study appear to be consistent with the average values reported in previous research examining the physical characteristics of children in similar age groups. Differences in the literature may be attributed to factors such as age, gender, nutritional status, the type and duration of exercise interventions. Considering the developmental stage of this age group, it is recommended that assessments take into account the relationship between height and body weight. In conclusion, it can be stated that regular physical activity may have positive effects on body composition parameters in children of this age group.

The right and left hand grip strength values of the children participating in the cross-country skiing exercise are presented in Table 3. When previous studies conducted on children in this age group are examined, similar findings are observed. For example, Özcan (2018), in a study involving 10–12-year-old students, reported that children who participated in a Nordic walking exercise program had a right-hand grip strength of 23.9 ± 0.6 kg in the pre-test and 25.2 ± 0.59 kg in the post-test. Left-hand grip strength values were 22.9 ± 0.57 kg in the pre-test and 23.8 ± 0.56 kg in the post-test. In the same study, arm strength assessed through a pull-up hanging test increased from 9.27 ± 1.2 sec in the pre-test to 17.4 ± 1.54 sec in the post-test. The researcher concluded that Nordic walking exercises had a positive effect on these parameters. In another study, Sevinç et al. (2015) examined 9–12 year-old taekwondo athletes and found that the competitive group had a right-hand grip strength of 19.74 ± 5.77 kg and a left-hand grip strength of 18.09 ± 5.82 kg, whereas the non-competitive group had grip strength values of 15.20 ± 2.63 kg for the right hand and 13.96 ± 2.84 kg for the left hand. Similarly, Can (2021) reported that badminton training had a positive effect on hand grip strength in children aged 10–12 years. In this context, the findings of our study regarding right and left hand grip strength are consistent with the existing literature. Numerous studies have indicated that participation in sports and exercise programs leads to an increase in grip strength in children. The increase in grip strength observed among children participating in cross-country skiing exercises in our study may be attributed to the regular use of ski poles during training.

The 30-meter sprint and T-agility pre-test and post-test values of the children who participated in cross-country skiing exercises in the study are presented in Table 4. When examining studies conducted on this age

group in the literature, Bozdağ and Kızılet (2017) reported agility values of 11.06 ± 0.79 seconds for boys and 12.30 ± 0.70 seconds for girls in 11–13-year-old badminton players. In another study, Göksu (2025) found that an 8-week educational game program had a positive effect on agility performance in 8–10-year-old children who did not participate in regular sports activities. There are also studies in the literature reporting that physical activity has a positive effect on agility and sprint performance (Yasamitsu et al., 2013; Jaimes et al., 2022; Özcan, 2018). Ara et al. (2004) found that 114 boys aged 9–14 who were physically active had better 30-meter sprint times compared to sedentary children.

Literature reviews reveal variations in 30-meter sprint values. Koç (2014) reported the average 30-meter sprint times of middle school students as 5.56 ± 0.51 seconds for boys and 6.44 ± 0.89 seconds for girls. In the findings of our study, a positive decline was observed in agility and sprint values in the cross-country skiing group; however, this change was not found to be statistically significant. In contrast, the decline observed in the walking group was found to be statistically significant. Since cross-country skiing is primarily an aerobic endurance-based sport, it can be suggested that it does not have a highly significant effect on agility and sprint performance. Moreover, the type and intensity of the physical activity performed may also have contributed to the observed differences.

The pre-test and post-test $VO_{2\max}$ values of the children who participated in the cross-country skiing exercise are presented in Table 5. In the literature, there are several studies reporting the positive effects of physical activity on oxygen consumption in children (Wang et al., 2023; Özcan, 2018; Karacabey, 2009). In another study, Enriquez et al. (2022) reported that a six-week training program improved the maximal oxygen consumption of 23 children aged 9–13. Bilgiç et al. (2016) determined the $VO_{2\max}$ value of children aged 11–13 years as 42.38 ± 7.31 ml/kg/min. In a study by Kocadağ (2014) investigating the effects of an eight-week football training program on the physical fitness levels of 14–16-year-old students, positive developments in aerobic endurance were observed by the end of the training period. The findings from the literature are consistent with the results obtained from the cross-country skiing and walking groups in our study. Since aerobic endurance is a key component in cross-country skiing, improvements in this parameter are to be expected. Overall, it has been observed that children who engage in physical activity and sports tend to have higher $VO_{2\max}$ levels compared to those who are inactive.

The pre-test and post-test values of static balance, standing long jump, and flexibility for the children participating in the cross-country skiing exercise are presented in Table 5. When examining studies conducted with this age group, Çakıroğlu (2011) reported that the experimental group of children aged 8–10 years achieved an average standing long jump distance of 138.77 ± 15.54 cm, while the control group averaged 127.4 ± 5.02 cm. Soğat (2007), in a study comparing children who participated in sports and those who did not, found flexibility values of 18.36 ± 5.97 cm in gymnasts, 15.63 ± 3.09 cm in basketball players, 13.43 ± 2.63 cm in handball players, and 9.59 ± 2.45 cm in non-athletes. Numerous studies in the literature have demonstrated that participation in physical activity positively affects flexibility, vertical jumping, and balance parameters (Karacabey, 2019; Kocadağ, 2014; Çabuk, 2024; Göksu & Arslan, 2024). The flexibility, standing long jump, and balance data from our study support these findings. Overall, participation in physical activity has had a positive effect on these parameters.

Conclusion

In conclusion, children who engaged in physical activity and sports showed greater improvements in average height compared with the control group. Regular exercise programs undertaken by children had a positive effect on body composition parameters. In addition to the exercise methods used for this age group, developmental characteristics and growth periods could play a major role in these outcomes.

The group participating in cross-country skiing exercises showed an increase in grip strength and upper body strength compared with the W and C groups. This improvement could be attributed to the use of poles during cross-country skiing training, which can positively influence grip strength. Furthermore, such training significantly contributes to the development of both the arms and upper body musculature. Furthermore, $VO_{2\max}$ was significantly higher in both the CCS and W groups compared with the C group. In general, children who engage in regular physical activity and sports have higher $VO_{2\max}$ than their physically inactive peers. Additionally, static balance and standing long jump scores were significantly higher in the CCS group compared with the other two groups. However, no significant differences were observed in participants' flexibility because of the exercise methods applied. Since balance is a key component in cross-country skiing, an improvement in balance was observed in the post-test results of participants who performed the exercises.

Based on the findings of this study, the 8-week cross-country skiing exercise program had a positive effect on the development of several physical fitness parameters, including height, right-hand and left-hand grip strength, hang time in the pull-up position, $VO_{2\max}$, static balance, and standing long jump distance among children aged 8–12 years, as evidenced by the differences between pre-test and post-test values. Considering the age range targeted in the study, this age period is regarded as crucial for physical development. Due to the movement kinematics involved in cross-country skiing, this type of exercise can be considered more developmentally supportive for this age group compared with walking or many other forms of physical activity.

Recommendations

- As a winter sport, cross-country skiing can serve as an alternative exercise method to help maintain children's physical activity levels and overall health during the colder months. Promoting this activity can help mitigate the negative effects of physical inactivity commonly observed in winter. Therefore, engaging in cross-country skiing during the winter season is recommended to support the continuity of physical activity throughout the year.
- Cross-country skiing exercises can be implemented to improve children's physical, physiological, motor, and health-related parameters.
- Based on our findings, cross-country skiing exercises can be integrated into various physical activity and health development programs to promote healthier living.
- Further studies with larger sample sizes can be conducted to examine the effects of such exercises in different age groups, particularly during adolescence.

Limitations

This study was limited to male students only; therefore, the results cannot be generalized to female children. Additionally, the wide age range of participants aged 8–12 years could have influenced physical fitness levels due to developmental differences. Furthermore, uncontrolled external factors, such as extracurricular physical activities, dietary habits, and sleep patterns might have affected the study outcomes.

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