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Original Research

An Investigation of the Sex Differences in Terms of Internal and External Loads in Orienteering Activities

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Abstract

Background: Orienteering has been growing in popularity and is considered to meet several of the needs of adolescents. Factors such as the type of terrain and the technical difficulty of the course affect the load in orienteering. In order to plan sports training regimes and recreational activities, it is crucial to know about the internal and external loads of the actions. Therefore, the purpose of this study is to investigate the sex differences in internal loads (heart rate) and external loads (distance covered at specific speeds) of the activities in orienteering. **Methods**: This study included 9 women with a mean age of 16.00 ± 0.83 years and 11 men with a mean age of 15.91 ± 1.22 years, who were all enrolled in a high school and who participated in school orienteering as a sports activity. The volunteer adolescents participated in the orienteering activity on a large, campus-like terrain that had a topographic map. The orienteering-specific goals were placed in this course at certain distances between them. Team Pro Polar was utilized to determine the participants' internal and external loads. The 'Mann-Whitney U' test was utilized for the comparison of the data obtained from the participants in terms of their sexes. **Results**: The orienteering activity was found to cause a high-level internal load in adolescents, but no statistically significant differences were found between the sexes ($p > 0.05$). Female course runners were found to cover distance mostly by walking and low-speed running. Men were found to cover longer distances than the women in moderate, high and maximum-speed running. **Conclusions**: The findings of this study show that orienteering is a physically challenging activity for both male and female adolescents. While the sexes were similar in terms of internal load, men were found to be exposed to a higher load in terms of their external load.

Keywords: orienteering; sex; internal load; external load

1. Introduction

Born in the age of a technology-dominated world, many Generation Z adolescents spend the majority of their time in front of computers, tablets, and phones. Besides, a decrease in green areas, as one of the negative effects of urbanization, has caused adolescents to spend more of their free time in closed areas such as shopping malls, cafeterias, game arcades, etc. In order to obtain a suitable career, adolescents in many countries of the world receive special education outside of school hours for their cognitive development. On the other hand, many students receive supplementary tutoring due to their parents finding the education provided at school inadequate, which increases the time students spend at desks and causes them to lead an even more inactive life in terms of physical activities.

Being physically inactive has become an important problem worldwide today. Physical inactivity, which is ranked fourth among the primary risk factors of this age, is reported to account for 6% of deaths in the scientific literature [1].

Adolescence represents a sensitive period in which lifestyle habits such as physical activity could have deep, long-term effects on the development and future lifestyle habits of young people. Adolescence is a period that includes frequent inactivity. In 2016, Sallis *et al.* [2] reported that around one-fourth of the adult population (23.3%) were physically inactive, and more than three-fourth of the young population (76.3% of adolescents, 78.4% of men, and 84.4% of women) were inactive.

The guide published by the Public Health Agency of the TR Ministry of Health stated that the proportion of those who never exercised in the 12–14 and 15–18 age groups were 41.4% and 44.6% respectively in men and 69.8% and 72.5% respectively in women in the same age group, and a further increase was reported with the increase in age [3].

An active lifestyle is known to have positive effects, such as a decrease in the prevalence of discomfort and illnesses, the improvement of health, and an increase in the length of life [1].

Sex is defined by human genotype and is related to the biological differences between men and women. Men usually have longer organs, stronger bones, bigger muscle mass and greater physical strength, with a greater aerobic capacity. On the other hand, women demonstrate less muscle fatigue and faster recovery during endurance exercises [4].

Women and men could participate in different types of physical activities according to their developmental periods, likes, and needs. A study reported that while secondary school female students were more active in individual sports, male students were more active in team sports [5].

Orienteering is a very fun and enjoyable recreational activity. Individuals who participate in this activity navigate around a certain terrain with the challenge of reading maps and determining the best route to follow and enjoy the environment. Orienteering is also a sport that has grown in popularity in recent years and is considered to meet several of the needs of adolescents. These needs may include the followings: performance of physical and mental activities in tandem, the need for outdoor activities, facilitating interaction with nature and environmental awareness, individual and social self-realization, and entertainment [6].

The orienteering activity provides a moderate, high, and submaximal load. Changes in the workload in orienteering (internal and external loads) are caused by the degree of incline in the terrain, the type of terrain, the types of vegetation that are present in the terrain, the necessity for constant direction changes due to natural obstacles, and technical difficulties of the course [7,8].

The literature on orienteering includes studies that investigated heart rate and various physiological parameters, but no studies were found to have investigated external load in recreational orienteering in adolescents [7–14].

Load is a physiological and psychological demand that is loaded into the organism through motor stimuli that result in the development and maintenance of high-performance capacity. Load also refers to bodily activities that cause the organism to work above normal. There are two components of the load, which inclues internal load referring to the relative pshysiological and psychological stress a sportsman is exposed to (heart rate, ratings of perceived exertion, etc.) and external load referring to the quantitative amount of work (volume, distance, etc.) [15].

Knowing about the load (internal and external) caused by the activities done for performance or recreational purposes is important for planning both training and fitness activities.

The purpose of this study is to investigate the sex differences in internal loads and external loads of the activities in orienteering.

2. Materials and Methods

2.1 Participants

This study included 9 female and 11 male high school students who participated in school orienteering as a sports activity and agreed to participate in the study. The mean age of the participants was 16.00 $\pm$ 0.83–15.91 $\pm$ 1.22 years, the average body weight was 54.77 $\pm$ 6.79–63.25 $\pm$ 13.84 kg, and the average height was 162.39 $\pm$ 3.59–172.86 $\pm$ 8.94 cm for women and men respectively. The research criteria were as follows: being healthy, having no orthopedic disabilities, and participated only in orienteering as a school activity. Before the measurements, first parents and then students were given the necessary information about the study and their written consent was received. The participants fully completed the study by participating in all the measurements.

2.2 The Orienteering Activity and Data Collection

The orienteering activities were carried out on the weekends, as the participating students attended school on weekdays. In order to ensure reliability of the data, this activity was organized on three successive weekends, and the average score of the activities was used for analysis. The Orienteering event was held on a large campus-like area. This terrain had sloping and straight roads, and is composed of trees, bushes and a few amount of buildings. 10 targets were randomly positioned in the terrain to be approximately 100 m away from each other. In the orienteering activity, the participants were given an orienteering-specific map produced from the topographic map and showing the targets. This is a 1/10,000 scale map with oriental-specific colors and symbols, as well as showing site-specific vegetation, rocks, water channels, electrical wires, buildings, and etc. The starting and finishing positions were located at the same point. The participants were given a map showing the location of the goals, which were removed from this point in one-minute intervals. Each participant was reminded that they raced against time. Since the order of the goals was different for each participant, orienteering-specific staples were utilized to check that they followed the goals in the right order. The participants' duration was recorded when they completed the goals respectively and came to the finish line. The participants did a 10 minute (min) all-body warm-up and then a 10-min cool down and stretch before the activity.

Internal load levels were determined using minimum, maximum, and average heart rates (beat/min) during the activity. External load was determined by total distance, distance covered at certain speeds, and mean and maximum speeds ($km \cdot h^{-1}$).

The Team Pro Polar (10 Hz GPS) system was utilized to record heart rate (HR, beat to beat) and movement speed (Polar Team Pro, Finland). The movements during the activity were determined at various speeds such as walking (<6 $km \cdot h^{-1}$), low-speed running (6.01–12 $km \cdot h^{-1}$), moderate-speed running (12.01–15 $km \cdot h^{-1}$), high-speed running (15.01–18 $km \cdot h^{-1}$) and sprint (>18 $km \cdot h^{-1}$) as the distance covered and total distances (different from the original source, as our system allowed 5 different intervals, jogging and low-speed running were combined) [16].

2.3 Statistical Analysis

Statistical analyses were performed in IBM SPSS for the Windows (v23, Armonk, NY, USA) program, and means, standard deviations, and mean rank values were used in all the data. The normality distribution of the data was tested using the Shapiro-Wilk test. As the data did not demonstrate normal distribution, the Mann-Whitney U test, a non-parametric independent samples *t*-test, was used for the comparisons by sexes. Statistical significance was ac-

cepted as $p < 0.05$ in all the analyses.

3. Results

Women seem to have a slightly higher internal load than men. Low values in terms of minimum, average, and maximum heart rates were found to be lower in male participants (Table 1). No statistically significant differences were detected between the sexes in terms of internal load in the orienteering activity.

Table 1. Comparison of internal load by sexes.

	Sex	Mean	Std. Dev.	Mean rank	z	*p*
HR min	Women	122.07	20.92	12.89	–1.63	0.10
	Men	108.30	19.19	8.55		
HR mean	Women	183.00	9.62	11.17	–0.46	0.65
	Men	179.18	11.98	9.95		
HR max	Women	201.26	7.13	10.94	–0.30	0.76
	Men	198.06	12.75	10.14		

*$p < 0.05$.

Women completed the orienteering course in a longer period than men. In this activity, while women covered 2578.00 m, men covered 2316.00 m in total distance. Women completed the orienteering course by walking (674.22 m), low-speed running (1213.00 m), moderate-speed running (482.00 m), high-speed running (165.00 m), and maximum-speed running (43.00 m). While men covered less distance in walking and low-speed running in comparison to women (377.76 m and 816.94 m respectively), they covered more distance at moderate-speed (616.39 m), high-speed (375.39 m) maximum-speed (129.55 m) running in comparison to women. While the average speed during the orienteering activity was 7.28 $km \cdot h^{-1}$ in women, it was 8.80 $km \cdot h^{-1}$ in men. At 23.29 $km \cdot h^{-1}$, the maximum speed was achieved by men. Except for moderate-speed running and maximum speed, all the variables indicated statistically significant differences between sexes in favor of men (Table 2).

4. Discussion

This study aimed to investigate the orienteering activity in adolescents in terms of internal and external loads and compare them by sexes.

Heart rate is a good indicator of exercise intensity. Factors such as the type of terrain present in the course, the course profile, and the technical difficulty of the course affect the intensity of the orienteering sport [9,10,17].

In spite of not being statistically significant, women's HR (mean and max) values were found to be slightly higher than those of men in this current study. This result could be explanied by the fact that women completed the orienteering course in a longer period than men (5 minutes longer on average). The intensity increased depending on the increase in the course duration, which may lead to an increase in HR among the women participants. Furthermore, higher HR means and HR maxes in both sexes could be caused by the field structure of the course and partly by its technical difficulty. Bird *et al*. [9] reported that even in races requiring slow running, the participants were reported to have an HR over 140 BPM for a long time, and they were found to have a HR of over 170 BPM in courses requiring rough and speed running. In their study that was conducted with female orienteers in different categories (national, club), Bird *et al*. [18] reported that the HR mean was 170–158 and the HR max 181–179 BPM, respectively. Another study that analyzed heart rates to determine internal loads found that the heart rate was between 140 and 180 BPM on average in orienteers who completed three courses with varying difficulties [9]. The literature results are in line with these findings, yet different heart rates in some studies could be caused by the participants' age differences.

The heart rates obtained in this study indicated that both sexes realized the orienteering activity with high intensity. Studies show that due to the nature of the orienteering sport including aerobic and anaerobic needs, orienteers decrease to 80% of their activity in a short time, but they spent 90% of their maximal [19].

Analysis results indicated no significant differences between sexes in terms of internal load, indicating that the orienteering course brought a similar internal load to both sexes. A study that monitored male orienteers in different race categories (aged 21 to 67) during two orienteering races with different technical difficulties indicated no differences between the categories and technical difficulties in terms of the HR mean score (159 BPM) and the HR max score (175 BPM) [18].

While women covered more distance and completed the course in a longer period in the orienteering activity with walking and slow-running, men covered more distance and completed the course in a shorter period with slow-moderate and high-speed running. Again, men covered more distance in maximum speed running in comparison to women. In line with these results, it can be concluded that men have more external load than women. In school football, while men spent time sprinting and high-speed running, women spent time walking, which caused men to have more external load than women [20]. Mckenzie *et al*. [21] reported that men were generally more active than women in exercises and games that required skills.

Both women and men preferred maximum speed running less than the other running types and covered very little distance in this running type. Since the participants arrived at the first goal point quickly and increased their speed to maximum when they were close to the finish point as they raced against time, the distances at these speeds are considered to be little. Hence, a study in the literature reported that during the orienteering activity, orienteers met their energy needs mainly aerobically and avoided long periods of

Table 2. Comparison of external load by sexes.

	Sex	Mean	Std. Dev.	Mean Rank	z	*p*
Orienteering course duration (mn:s)	Women	21:58	04:12	14.89	–3.00	0.01*
	Men	16:26	02:25	6.91		
Total distance (m)	Women	2578.00	343.57	14.33	–2.62	0.01*
	Men	2316.00	109.45	7.36		
Walking (m)	Women	674.22	223.89	14.33	–2.62	0.01*
	Men	377.76	193.54	7.36		
Low-speed running (m)	Women	1213.00	256.48	15.00	–3.08	0.01*
	Men	816.94	194.89	6.82		
Moderate-speed running (m)	Women	482.11	91.74	7.78	–1.86	0.06
	Men	616.39	174.53	12.73		
High-speed running (m)	Women	165.67	91.61	6.89	–2.47	0.01*
	Men	375.39	204.43	13.45		
Maximum-speed running (m)	Women	43.26	50.07	7.56	–2.01	0.04*
	Men	129.55	87.50	12.91		
Mean speed ($km \cdot h^{-1}$)	Women	7.28	0.65	6.67	–2.62	0.01*
	Men	8.80	1.36	13.64		
Maximum speed ($km \cdot h^{-1}$)	Women	20.67	1.78	7.89	–1.79	0.07
	Men	23.29	3.71	12.64		

*$p < 0.05$; mn:s, minute:second.

high-speed [22].

Mean and maximum speeds were found to be higher in men (8.80 and 23.29 $km \cdot h^{-1}$). This result is somewhat expected, since men completed the course in a shorter time (around 5 minutes earlier than women). As the running speed in orienteering is affected by direction-finding tasks, men's better performance in spatial orientation tasks [23] might contribute to the running speed and total distance differences between sexes. Women covered longer total distance than men. Women's decreasing their speed as they get closer to the target and covering more distance to find the goals could have caused differences in speed and total distance. A study reported a relationship between finishing the course in a shorter time and a higher speed of running, which is considered to be a good indicator of predicting the performance [17].

Previous research reported that orienteers demonstrated a 6–12 $km \cdot h^{-1}$ mean speed in the course and reached a maximal 20.7 $km \cdot h^{-1}$ speed [11,17,22,24–26]. This course, organized for recreational purposes, demonstrated a similar average speed of adolescents to the findings in the literature. On the other hand, findings concerning the maximum speed in this study demonstrate differences from the related literature. The differences are considered to result from orienteers' race category, age, course type, terrain structure (forest, road, etc.), course length, and duration of completion. Studies reported a highly positive relationship between the race length and running speed, and short courses caused orienteers to become slower, and the increase in the technical difficulties of the course caused slower running speeds for both sexes [27]. Course performance could be increased by stable running along the course instead of demonstrating changeable speeds between goals in orienteering. Faster orienteers in the course among orienteers in different categories were found to have those who demonstrated more stabile running [28]. A study reported that the increase in the intensity of the field structure (plant, tree, etc.) caused a slowdown in the speed [29].

This study was limited to adolescents participants with three orienteering courses. Future studies may focus on the effects of orienteering courses on internal and external loads with different age groups and sessions. Moreover, internal load was limited to heart rate measurement and external load was limited to distance covered at specific speeds.

5. Conclusions

The findings of this study show that orienteering is a physically challenging activity for both male and female adolescents, and it brought similar loads to sexes in terms of internal load. While women covered more distance by walking and slow-running, men covered more distance by slow-moderate and high-speed running. Besides, men demonstrated more mean and maximum speeds in comparison to women. Therefore, men's external load was higher than women.

The orienteering activity in this study was prepared for reactive purposes and the study was conducted only with adolescents, which are considered to be the limitations of the study.

Although this study is descriptive in nature, it provides insights into the demonstration of the internal and external

loads of a group with these characteristics.

Author Contributions

The author is responsible for the whole article.

Ethics Approval and Consent to Participate

The study was conducted in line with the guidelines of the Declaration of Helsinki and approved by the Hatay Mustafa Kemal University Ethics Committee (2021/11).

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Conflict of Interest

The author declares no conflict of interest.

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