

Acute responses to repeated sprints on a non-motorized treadmill on dominant- and non-dominant leg sprint parameters

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

Abstract

Background and Study Aim The aim of this study was to examine the acute responses to repeated sprints on a non-motorized treadmill on dominant leg (DL) and non-dominant leg (NDL) sprint parameters.

Material and Methods Volunteered students from Sports Sciences Faculty were randomly divided into experimental group (EG) and control group (CG). As pre- and post-tests, each participant performed 30m sprint test on a non-motorized treadmill. There were 6x20m with 1min on a non-motorized treadmill as repetitive sprints. As a statistical analysis, whether there is pre-test and post-test differences were analysed with independent t test between the groups and paired t test within the groups. The level of significance was taken as $p \leq 0.05$.

Results In comparisons within the groups, both groups had significant pre- and post-test differences in parameters of time (t), velocity (V), and power (P) [for EG, $p < 0.001$, $p < 0.001$, and $p < 0.001$; for CG, $p < 0.001$, $p < 0.001$, and $p < 0.01$, respectively]. CG had significant pre- and post-test differences in parameters of stride length (SL) and horizontal force (HF) ($p < 0.05$). There were no statistically significant pre-test differences in 30m sprint parameters of NDL and DL. In post-tests, there were only significant differences in SL_{DL} , HF_{DL} , P_{NDL} , and P_{DL} ($p < 0.05$, $p < 0.05$, $p < 0.05$, and $p < 0.01$, respectively). CG had only significant pre- and post-test differences in SL_{NDL} and SL_{DL} within the group's comparisons ($p < 0.05$). Either EG or CG had significant pre- and post-test differences in P_{DL} ($p < 0.05$).

Conclusions In conclusion, repeated sprints may exhibit shorter strides to overcome horizontal resistance and fatigue, resulting in reduced SL and greater P exerted in the DL.

Keywords: stride frequency, stride length, vertical force, horizontal force, power

Introduction

Short-term sprints involving short recovery are common in many sports. The ability to produce the best possible average sprint performance over a series of sprints separated by recovery periods has also been referred to as repeated sprint ability [1]. Repetitive sprint ability is an important physical fitness requirement of athletes in all branches, and it is necessary to understand the training strategies that can improve this physical fitness component. Therefore, sprint tests have an important effect on testing anaerobic performance, monitoring and evaluating strength and power athletes [2]. Studies [3, 4, 5] reported that repeated sprint training reduces the best sprint and average sprint time. Hoffman [6] suggested various laboratory and field tests as valid and reliable tests of sprint performance. Chamari et al. [7] stated that laboratory tests are advantageous compared to field tests as they are more sensitive and reliable in the evaluation of athletes. Janaudis-Ferreira de et al.

[8] study showed that non-motorized treadmills could be a practical approach for testing sport-specific movement patterns such as sprinting. With the development of non-motorized treadmill ergometry, laboratory testing of repetitive sprints became possible [9, 10]. In addition, most of these treadmills, which enable the athletes to reveal the maximum sprint speed in laboratory conditions, are equipped with force transducers that can obtain force, speed and power data on their platform [2].

Since the relative bilateral differences in muscle force, movement, flexibility, balance, and mechanics between the two sides of the body affect the athlete's whole-body balance, non-motorized treadmills contribute to the symmetrical and asymmetrical anaerobic power assessment of the body. In determining the sprint performance of an athlete, there are factors such as stride frequency, stride length, foot placement, contact angle and imbalance between strides. Changes in balance during the movements on the treadmill can cause falls and injury [11]. Therefore, it is important to maintain the body stability and balance during the movements. Hatchett et al. [12] showed that

imbalances occur when fatigue accumulates during sprinting on non-motorized treadmills, and as the stride length decreases and the speed remains constant, the time spent by both lower extremities for the ground support also decreases.

The effects of repeated sprints on a non-motorized treadmill to post-exercise recovery [13, 14], energy expenditure [15], power output [16], peak and mean power [17], and fatigue level [18] are investigated but there is no study revealing its acute effects on the dominant and non-dominant leg sprint parameters.

Purpose of the Study. Because of these reasons, the study purpose was to investigate acute responses to repeated sprints on a non-motorized treadmill on dominant- and non-dominant leg sprint parameters.

Materials and Methods

Participants

Fifty male Faculty of Sports Sciences students from Eskişehir Technical University, having no experience about a sprint test on the non-motorized treadmill and being physically active at easy-medium level (weekly ≤ 3 session aerobic activity), participated in this study. The target minimum number of participants was decided with the G*Power 3.1.9.7 analysis based on the data given a required power ($1 - \beta$) of 0.80, a type I error or alpha level, $\alpha = 0.05$, and an effect size (d) of 0.80. Four participants from each group excluded from the study because of missing values. The participants were randomly divided into two groups [experimental group (EG) ($n = 21$, age = 19.9 ± 2.4 year, body height = 174.8 ± 6.6 cm, body weight = 66.2 ± 5.8 kg and control group (CG) ($n = 21$, age = 20.2 ± 2.1 year, body height = 172.7 ± 7.0 cm, body weight = 64.2 ± 5.9 kg)]. The participants were free to discontinue the study at any time. Participants were asked to maintain their normal dietary intake, to avoid any strenuous exercise in the 48 h before the experimental sessions, and avoid smoking, alcohol and caffeine consumption for 24 h before all tests. Written informed consents were obtained from the participants in accordance with the principle of Helsinki Declaration after the procedures and probable risks had been explained to them. The study was approved by İstanbul Nişantaşı University Ethics Committee (2022/24) prior to the commencement of testing. The participants were randomly participated into the test protocols.

Research Design

Before trial and actual measurements and tests of the participants, each device was calibrated. Each participant participated in tests and repetitive sprints for trial and familiarization one week before study. After a 10-min individual warm-up consisting of jogging, stretching, and mobility movements, 2x30m sprint tests with 3-min interval on a non-

motorised treadmill as stated by Kaçoglu and Kale [19]. The best of the 2 trials was taken into statistical analysis. After three days of break, before post-tests, EG performed 6x20 m repetitive sprints with 1 min passive rest intervals. CG was rested without repetitive sprints. The 2x30m sprint tests were repeated with the same protocols after a passive rest for 90 sec following the repetitive sprints.

Repetitive Sprints

Each participant in EG performed 6x20 m repetitive sprints at 1 min intervals on a non-motorized computer-assisted treadmill (Woodway Force 3.0, Woodway Inc., Waukesha, USA) after 10 min free warm-up consisting of jogging, stretching and mobility movements. Before the test, the belt was attached to the waist according to the height of the participants and the horizontal force strain gauge was adjusted parallel to the treadmill. Stride frequency, stride length, vertical and horizontal force, and power data obtained during each 20 m sprint were recorded.

Body Height and Body Weight Measurements

The body height, using a wall-mounted stadiometer (Holtain, UK) with an accuracy of ± 0.1 mm, and the body weight, using the electronic laboratory scale (Seca, Vogel & Halke, Hamburg) with an accuracy of ± 0.1 kg, were measured according to Lohman et al. [20].

Sprint Test

Subjects were participated to 2x30 m sprint test with a 3 min interval on a non-motorised computer assisted treadmill (Woodway Force 3.0, Woodway Inc., USA) after 10 min warm-up consisting of light tempo running, stretching, and mobility exercises. Before testing, the HF strain gauge was adjusted parallel to treadmill based on the waist level. The best 30 m sprint result was statistically analysed. Thirty-meter sprint speed was calculated with $(V_{\text{mean}}) = \text{distance (d)} / \text{time (t)}$ in terms of $\text{m} \cdot \text{s}^{-1}$. During 30 m sprint, mean HF (HF_{mean}) and mean VF (VF_{mean}) data were recorded to computer at 200 Hz. HF_{mean} was calculated with 30 m sprint total HF/30m sprint total stride number formula in terms of Newton. VF_{mean} was calculated with 30 m sprint total VF/30m sprint total stride number formula in terms of Newton. Same calculation method was used for all other sprint parameters of both legs that are mean SF (SF_{mean}), mean SL (SL_{mean}), mean W (W_{mean}) and mean P (P_{mean}), and also DL and NDL that are dominant leg SF (SF_{DL}), non-dominant leg SF (SF_{NDL}), dominant leg SL (SL_{DL}), non-dominant leg SL (SL_{NDL}), dominant leg HF (HF_{DL}), non-dominant leg HF (HF_{NDL}), dominant leg VF (VF_{DL}), non-dominant leg VF (VF_{NDL}), dominant leg W (W_{DL}), non-dominant leg W (W_{NDL}), dominant leg P (P_{DL}), non-dominant leg P (P_{NDL}).

Statistical Analysis

Data analysis was conducted with SPSS 22 (SPSS Inc., Chicago, IL, USA). Kolmogorow Smirnow test for normalization and Levene test for homogeneity were used in pre-test results. Intra-group pre- and post-test results compared with independent sample t test, and inter-group pre- and post-test results compared with paired sample t test. Statistical significance level was determined by an alpha level $p \leq 0.05$. Cohen's d effect size (ES) was determined by analysing from mean and standard deviation and classified as: trivial (<0.20), small (0.20 to 0.49), medium (0.50 to 0.79) or large (≥ 0.80) as described by Wassertheil and Cohen [21].

Results

Each parameter in the pre-tests was normally distributed for both groups ($p < 0.05$). All results are presented in Table 1, Table 2, and Table 3.

There were no significant statistical pre-test differences in V_{peak} , HF_{peak} , VF_{peak} , and P_{peak} but V_{peak} , and P_{peak} had significant post-test differences between EG and CG (ES: large, $p < 0.01$ and ES: moderate, $p < 0.05$; respectively) (Table 1). Both groups had statistically significant pre- and post-test differences in V_{peak} within the group comparisons (for EG, ES: moderate, $p < 0.001$ and for CG, ES: small, $p < 0.001$).

Table 2 showed that there were no significant pre-test differences in 30m sprint parameters between the groups but parameters t, V, SL, HF, and P had significant post-test differences (ES: large, $p < 0.001$; ES: large, $p < 0.001$; ES: moderate, $p < 0.05$; ES: moderate, $p < 0.05$, and ES: moderate, $p < 0.01$; respectively). In comparisons within the groups, both groups had significant pre- and post-test differences in t, V, and P parameters (for EG, ES: moderate, $p < 0.001$; ES: large, $p < 0.001$, and ES: moderate, $p < 0.001$; for CG, ES: moderate, $p < 0.001$; ES: moderate, $p < 0.001$, and ES: moderate, $p < 0.01$, respectively). In addition, there were significant pre- and post-test differences in SL and HF parameters in CG (ES: small, $p < 0.05$ and ES: small, $p < 0.05$, respectively).

Table 3 demonstrated that there were no statistically significant pre-test differences in 30m NDl and DL sprint parameters. In post-tests, there were only significant differences in SLDL, HFDL, PNDL, and PDL (ES: moderate, $p < 0.05$; ES: moderate, $p < 0.05$; ES: moderate, $p < 0.05$, and ES: moderate, $p < 0.01$, respectively). CG had only significant pre- and post-test differences in SLNDL and SLDL within the group's comparisons (ES: small, $p < 0.05$ and ES: small, $p < 0.05$, respectively). Either EG or CG had significant pre- and post-test differences in PDL (ES: small, $p < 0.05$ and ES: moderate, $p < 0.05$, respectively).

Table 1. Mean $\pm$ SD values and comparisons of peak parameters of 30m sprint pre- and post-tests for two groups

Parameters	Group	Pre	Post	ES [95% CI]	Inference
V_{peak}	EG	5.19 $\pm$.21	5.03 $\pm$.19***	0.80 [0.08, 0.26]	moderate
	CG	5.18 $\pm$.26	5.34 $\pm$.29*** ¥ ¥	0.58 [-0.24, -0.06]	small
	ES [95% CI]	0.00 [-0.14, 0.15]	1.27 [-0.47, -0.17]		
	Inference	Trivial	large		
HF_{peak}	EG	517 $\pm$ 90	478 $\pm$ 100	0.41 [-9, 86]	small
	CG	476 $\pm$ 93	489 $\pm$ 59	0.17 [-60, 35]	trivial
	ES [95% CI]	0.45 [-17, 97]	0.13 [-62, 41]		
	Inference	Small	trivial		
VF_{peak}	EG	1876 $\pm$ 303	1925 $\pm$ 335	0.15 [-116, 16]	trivial
	CG	1956 $\pm$ 250	1906 $\pm$ 249	0.20 [-59, 160]	small
	ES [95% CI]	0.29 [-254, 93]	0.06 [-165, 204]		
	Inference	Small	trivial		
P_{peak}	EG	1894 $\pm$ 355	1797 $\pm$ 353	0.27 [-50, 244]	small
	CG	1895 $\pm$ 441	2015 $\pm$ 335 ¥	0.31 [-251, 12]	small
	ES [95% CI]	0.04 [-251, 248]	0.63 [-432, -3]		
	Inference	trivial	moderate		

Data are Mean $\pm$ SD. EG: Experimental group; CG: Control group; ES: Effect size; 95% CI: 95% Confidence interval; V_{peak} : Peak velocity; HF_{peak} : Peak horizontal force; VF_{peak} : Peak vertical force; P_{peak} : Peak power; ***: $p < 0.001$, within groups; ¥: $p < 0.05$, between groups; ¥¥: $p < 0.01$, between groups.

Table 2. Mean $\pm$ SD values and comparisons of parameters of 30m sprint pre- and post-tests for two groups

Parameters	Group	Pre	Post	ES [95% CI]	Inference
t	EG	6.38 $\pm$.27	6.70 $\pm$.31***	1.10 [-0.48, -0.17]	moderate
	CG	6.52 $\pm$.26	6.28 $\pm$.30*** ^{¥¥¥}	0.86 [0.15, 0.33]	moderate
	ES [95% CI]	0.53 [-0.31, 0.02]	1.38 [0.23, 0.61]		
	Inference	small	large		
V	EG	4.72 $\pm$.20	4.48 $\pm$.19***	1.23 [0.13, 0.34]	large
	CG	4.61 $\pm$.19	4.79 $\pm$.23*** ^{¥¥¥}	0.85 [-0.25, -0.11]	moderate
	ES [95% CI]	0.81 [-0.01, 0.23]	1.47 [-0.44, -0.17]		
	Inference	moderate	large		
SF	EG	6.81 $\pm$.89	6.73 $\pm$ 1.02	0.08 [-0.32, 0.47]	trivial
	CG	6.43 $\pm$.87	6.33 $\pm$.90	0.11 [-0.12, 0.33]	trivial
	ES [95% CI]	0.43 [-0.18, 0.92]	0.42 [-0.19, 1.01]		
	Inference	small	small		
SL	EG	.79 $\pm$.13	.76 $\pm$.15	0.21 [-0.05, 0.10]	small
	CG	.81 $\pm$.12	.86 $\pm$.13* [¥]	0.40 [-0.09, 0.00]	small
	ES [95% CI]	0.16 [-0.10, 0.05]	0.71 [-0.18, -0.01]		
	Inference	trivial	moderate		
HF	EG	146 $\pm$ 9	144 $\pm$ 11	0.20 [-1, 6]	small
	CG	147 $\pm$ 10	152 $\pm$ 14* [¥]	0.41 [-10, 0]	small
	ES [95% CI]	0.11 [-7, 5]	0.64 [-16, -0]		
	Inference	trivial	moderate		
VF	EG	648 $\pm$ 95	646 $\pm$ 91	0.02 [-10, 13]	trivial
	CG	670 $\pm$ 71	666 $\pm$ 67	0.06 [-21, 29]	trivial
	ES [95% CI]	0.26 [-74, 31]	0.25 [-69, 31]		
	Inference	small	small		
P	EG	702 $\pm$ 64	660 $\pm$ 70***	0.63 [19, 64]	moderate
	CG	690 $\pm$ 76	748 $\pm$ 97*** ^{¥¥}	0.67 [-89, -27]	moderate
	ES [95% CI]	0.17 [-33, 55]	1.04 [-141, -36]		
	Inference	trivial	moderate		

Data are Mean $\pm$ SD. EG: Experimental group; CG: Control group; ES: Effect size; 95% CI: 95% Confidence interval; t: time; V: Velocity; SF: Stride frequency; SL: Stride length; HF: Horizontal force; VF: Vertical force; P: Power; *: $p < 0.05$, within groups; **: $p < 0.01$, within groups; ***: $p < 0.001$, within groups; ¥: $p < 0.05$, between groups; ¥¥: $p < 0.01$, between groups; ¥¥¥: $p < 0.001$, between groups.

Discussion

The aim of this study was to examine the acute responses to repeated sprints on a non-motorized treadmill on dominant leg (DL) and non-dominant leg (NDL) sprint parameters. A decrease was found for the experimental group post-test 30m sprint peak parameters VF_{peak} and P_{peak}. In addition, EG had a statistically significant difference ($p < 0.001$) between the pre- and post-tests in t, V and P due

to the decrease in the 30 m sprint parameter post-test values. EG also showed lower values than CG in SL_{DL}, YK_{BB}, P_{NDL} and P_{DL} parameters in the post-tests. The present study was supported by Buchheit et al. [14] found an increase in sprint time in a 6x4 s repetitive sprint performed on a non-motorized treadmill. Girard et al. [22] revealed that fatigue symptoms seen in sprints due to the decrease in working capacity during repeated

Table 3. Mean $\pm$ SD values and comparisons of NDL and DL parameters of 30m sprint pre- and post-tests for two groups

Parameters	Group	Pre	Post	ES [95% CI]	Inference
SF _{NDL}	EG	6.78 $\pm$ 1.02	6.63 $\pm$ 1.09	0.14 [-0.33, 0.64]	trivial
	CG	6.50 $\pm$.90	6.40 $\pm$.97	0.11 [-0.19, 0.38]	trivial
	ES [95% CI]	0.39 [-0.32, 0.88]	0.22 [-0.42, 0.87]		
	Inference	small	small		
SF _{DL}	EG	6.83 $\pm$.91	6.84 $\pm$ 1.05	0.01 [-0.44, 0.42]	trivial
	CG	6.36 $\pm$.90	6.25 $\pm$.92	0.44 [-0.15, 0.37]	small
	ES [95% CI]	0.52 [-0.10, 1.04]	0.60 [-0.03, 1.21]		
	Inference	small	moderate		
SL _{NDL}	EG	.77 $\pm$.13	.75 $\pm$.14	0.15 [-0.05, 0.09]	trivial
	CG	.78 $\pm$.11	.82 $\pm$.13*	0.33 [-0.09, 0.00]	small
	ES [95% CI]	0.08 [-0.08, 0.07]	0.52 [-0.16, 0.01]		
	Inference	trivial	small		
SL _{DL}	EG	.79 $\pm$.13	.76 $\pm$.16	0.21 [-0.05, 0.11]	small
	CG	.82 $\pm$.12	.87 $\pm$.14* [¥]	0.38 [-0.10, -0.01]	small
	ES [95% CI]	0.24 [-0.11, 0.05]	0.73 [-0.21, -0.02]		
	Inference	small	moderate		
HF _{NDL}	EG	143 $\pm$ 14	145 $\pm$ 19	0.12 [-13, 8]	trivial
	CG	149 $\pm$ 18	148 $\pm$ 22	0.05 [-9, 9]	trivial
	ES [95% CI]	0.37 [-16, 4]	0.15 [-16, 9]		
	Inference	small	trivial		
HF _{DL}	EG	149 $\pm$ 18	142 $\pm$ 18	0.39 [-3, 17]	small
	CG	147 $\pm$ 16	155 $\pm$ 21 [¥]	0.43 [-20, 4]	small
	ES [95% CI]	0.12 [-8, 13]	0.67 [-24, -0]		
	Inference	trivial	moderate		
VF _{NDL}	EG	690 $\pm$ 180	653 $\pm$ 208	0.19 [-96, 170]	trivial
	CG	662 $\pm$ 141	714 $\pm$ 125	0.39 [-126, 22]	small
	ES [95% CI]	0.17 [-73, 129]	0.36 [-168, 46]		
	Inference	trivial	small		
VF _{DL}	EG	625 $\pm$ 187	640 $\pm$ 210	0.08 [-152, 122]	trivial
	CG	677 $\pm$ 117	617 $\pm$ 132	0.48 [-25, 146]	small
	ES [95% CI]	0.33 [-150, 45]	0.13 [-86, 132]		
	Inference	small	trivial		
P _{NDL}	EG	676 $\pm$ 73	653 $\pm$ 96	0.27 [-24, 70]	small
	CG	681 $\pm$ 81	724 $\pm$ 114 [¥]	0.44 [-90, 5]	small
	ES [95% CI]	0.07 [-53, 43]	0.67 [-136, -5]		
	Inference	trivial	moderate		
P _{DL}	EG	727 $\pm$ 106	667 $\pm$ 98*	0.59 [7, 112]	small
	CG	697 $\pm$ 97	772 $\pm$ 116* ^{¥¥}	0.70 [-132, -18]	moderate
	ES [95% CI]	0.30 [-33, 94]	0.98 [-172, -38]		
	Inference	small	moderate		

Data are Mean $\pm$ SD. EG: Experimental group; CG: Control group; ES: Effect size; 95% CI: 95% Confidence interval; SF_{NDL}: Non-dominant leg stride frequency; SF_{DL}: Dominant leg stride frequency; SL_{NDL}: Non-dominant leg stride length; SL_{DL}: Dominant leg stride length; HF_{NDL}: Non-dominant leg horizontal force; HF_{DL}: Dominant leg horizontal force; VF_{NDL}: Non-dominant leg vertical force; VF_{DL}: Dominant leg vertical force; P_{NDL}: Non-dominant leg power; P_{DL}: Dominant leg power; *: p<0.05, within groups; ¥: p<0.05, between groups; ¥¥: p<0.01, between groups.

sprints appear as a decrease in maximum speed and peak power. Although sprints performed in training or competitions are efforts not exceeding a few seconds (≤ 6 sec), they often require very short recovery intervals (15-90 sec). This is especially determinative of the alactic anaerobic endurance of the athletes in this type of high-intensity activity, which is repeated with the resynthesis capacity of the phosphogen system (ATP-CP) and creatine phosphate (CP) [23]. Considering that the amount of creatine phosphate in the muscle is a limiting factor physiologically in demonstrating repetitive sprint performance [24] and recovery speed and recovery level are effective in demonstrating high intensity performance, the decrease in these parameters after repeated sprinting in DG may be caused by fatigue due to decreased creatine phosphate stores. As Lakomy [10] stated, since the force and power required to move the non-motorized treadmill at a constant speed increase rapidly, the more power applied to the treadmill, the higher the acceleration. The reason for the time and power losses in DG may be the decrease in the power applied to the treadmill due to fatigue and the decrease in speed accordingly. Sprint speed is a combination of SL and SF [25], and SF is reported as the speed-limiting factor in sprinting [26, 27, 28, 29]. In addition, the ground reaction force is affected by the increase in sprint speed provided by changes in SL and SF [30, 31, 32]. The results of this study supported studies [33, 34] showing that the SF increased as the sprint speed increased from the minimum to the maximum, and the SL remained the same or slightly decreased. However, SF may be the dominant factor in short duration sprints of 3-5 sec, as long-term force and power development (e.g. ground reaction force and impulse) is required to reach a higher sprint speed with a longer SL. The vertical speed, which is the primary source of the negative relationship between SL and SF, is largely determined by the ground reaction force and impulse. However, the athlete must have the neuromuscular ability to accelerate

and slow the lower limbs. The important role here is the eccentric strength of the hamstring muscles and hip flexors [29]. The magnitude of the vertical speed can also affect fatigue. Therefore, the SL and power losses of DG may be due to fatigue. Since the difference in DL and NDL muscle thickness is associated with longer fascicle length of the DL [35, 36], using one leg preferentially over the other in training also effects not only increases muscle thickness but also muscle fascicle length. Longer fascicle length may be associated with greater muscle strength and joint torque in DL, as muscle fascicle length is a significantly related to torque due to maximum isometric contraction [36]. Gür et al. [37], Hansen et al. [38], Mogroni et al. [39] also reported that skeletal muscle architecture has a significant effect on the force/velocity relationship of the muscle system and sarcomeres that produce joint torque.

Conclusions

Performing in repetitive sprints with shorter strides and transferring the load to the DL to counter horizontal resistance may be the reason why SL is decreased and more force is applied in the DL as resistance to fatigue. The increase in t and decrease in P from the results of the study's 30m sprint parameters support this idea. However, the lack of studies in the literature that includes repetitive sprint performance applied on a non-motorized treadmill has limited the discussion and more detailed studies are needed on other sprint parameters.

Acknowledgement

This present paper was supported by İstanbul Nişantaşı University Scientific Research Projects by Project 2022/14.

Conflict of interest

The authors declare no conflicts of interest.

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Cite this article as:

Kale M, Aktürkoğlu K, Yol Y, Kızıldağ Kale E. Acute responses to repeated sprints on a non-motorized treadmill on dominant- and non-dominant leg sprint parameter. *Physical Education of Students*, 2023;27(5):230–237. <https://doi.org/10.15561/20755279.2023.0502>

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Received: 12.08.2023

Accepted: 18.09.2023; **Published:** 30.10.2023