ASSESSMENT OF IMPACT OF ACTIVATION OF HIP JOINT ABDUCTORS AND EXTERNAL ROTATORS ON GAIT AND RUNNNING PARAMETERS IN HEALTHY PEOPLE. PILOT STUDY

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Abstract

Many physiotherapists and motor preparation coaches recommend including resistance exercises for the hip joint abductors and external rotators in a warm-up. Muscle activation with resistance band exercises is believed to improve positional control of the pelvis and the lower limbs, thus reducing the risk of musculoskeletal injury during rehabilitation or training proper. The aim of this study was to assess the impact of a single session of activation of hip joint abductors and external rotators on gait and running parameters in healthy people. The study involved 54 healthy individuals aged 19-21 years. An experimental group (Group 1) performed a set of 6 resistance exercises with Thera rubber bands, intended to activate the hip joint abductors and external rotators. A control group (Group 2) performed the same set of exercises but without external resistance. A walking and running gait examination was performed on a Zebris FDM treadmill in both groups before and after the exercises. Both variants of exercises produced changes in selected gait parameters ($p<0.05$). An examination of running gait in Group 1 revealed an increase in step length in the dominant limb ($p<0.05$) and stride length ($p<0.05$) and step time in the dominant limb ($p<0.05$), stride length ($p<0.05$) and cadence ($p<0.05$). Heel pressure also decreased in both limbs, and heel pressure force decreased in the non-dominant limb ($p<0.05$). A running gait examination in Group 2 revealed increased midfoot pressure force in both limbs ($p<0.05$). Thus, a single session of exercises with resistance banding to activate the hip joint abductors and external rotators exerted an effect on running parameters, which may improve running economy.

Keywords: *hip joint abductors, gluteus medius, mini loop resistance bands, gait analysis, running gait analysis*

Introduction

Impaired positional control of the pelvis and hip joint plays a significant role in the mechanism underlying lower limb injuries, especially in athletes. The gluteus medius is considered the most important muscle responsible for normal pelvic positioning in the frontal plane. Gluteus medius morphology serves to generate large abducting torques in the hip joint, which is of key importance for maintaining a normal position of the femur with regard to the pelvis in the frontal plane (Flack, Nicholson, & Woodley, 2014). Impaired function of the hip joint abductors and external rotators may contribute to poor control of pelvic position in the frontal plane and excessive adduction of the hip joint, and, consequently, lead to musculoskeletal strain and injuries. It has been demonstrated that low back pain sufferers have a weaker gluteus medius (Sadler, Cassidy, Peterson, Spink, & Chuter, 2019) and that individuals with hip osteoarthritis have weaker or atrophic hip joint abductors (Zacharias, Pizzari, Semciw, English, Kapakoulakis, & Green, 2019), and that impaired strength of these muscles in patients following hip arthroplasty may cause a limping gait (Nankaku, Tsuboyama, Aoyama, Kuroda, Ikeguchi, & Matsuda, 2016). Changes in gluteal muscle activity during gait have also been reported in postmenopausal women with greater trochanteric pain (Ganderton, Pizzari, Harle, Cook, & Semciw, 2017). Khayambashi et al. noted that poorer isometric strength scores for the hip joint abductors and external rotators in athletes predispose them to non-contact injuries to the anterior cruciate ligament (Khayambashi, Ghoddosi, Straub, & Powers, 2016). Asymmetry in gluteal muscle activity has been reported in individuals with patellofemoral pain syndrome (Payne, Payne, & Larkin, 2020). Patients with chronic instability of the ankle joint were reported to have reduced gluteus medius activity in the stance phase of gait (De Jong, Mangum, & Hertel, 2019). Exercises intended to strengthen the hip joint abductors and external rotators are an important component of rehabilitation programs offered to patients following lower limb injuries. Training the muscles that stabilize the pelvis and the hip joints is viewed as a strategy for preventing musculoskeletal injury and strain, especially in the lower limbs. However, research data do not always confirm the effectiveness of this approach. Park et al. assessed the outcomes of a program including resistance exercises for the gluteus medius muscles in patients following arthroscopic interventions on account on meniscal injuries (Park, Kim & Kim, 2016), finding improved strength of the hip abductors, but no improvement in balance parameters.

Many physiotherapists and motor preparation coaches use resistance exercises for the hip joint abductors and external rotators in a warm-up before a session of kinesiotherapy or sports practice. The goal of exercises with elastic resistance bands is not to produce fatigue in the muscle groups involved, but to activate these muscles so that they could work more efficiently in the following session of therapy or sports practice. Enhanced stability of the pelvis and the hip joint is believed to improve the conditions of axial loading of the lower limbs and thus reduce the risk of strain and training-related injuries.

To verify the feasibility of this approach, a study was conducted to assess whether a single exercise session to activate the hip abductors and external rotators with the subjects wearing resistance bands would have an effect on selected parameters of walking and running gait in healthy individuals.

Methods

The study enrolled 60 healthy individuals aged 19–21 years who had declared practicing recreational sports once or twice a week for at least a year. The exclusion criteria comprised musculoskeletal dysfunctions, pain or surgery within the 6 months preceding the study. The participants were randomized into 2 groups (by randomly assigning the numbers 1 or 2 to consecutive enrollees). The study, including a walking and running gait analysis, was completed by 54 individuals. Group 1 was an experimental group of 29 individuals (17 women, 12 men) aged 20.17 ± 0.75 years. A control group (Group 2) consisted of 25 participants (16 women and 9 men) aged 20.04 ± 0.88 years. The dominant lower limb was identified in a test consisting of three tasks (kicking a ball, moving a sheet of paper and stamping the foot as if to extinguish a fire) where performing at least two of the tasks with the same limb determined that limb as dominant. Relevant characteristics of the two groups are shown in Table 1.

Table 1. Characteristics of study participants

Group	Age (years)	Height (cm)	Weight (kg)	BMI
Group 1 (n=29)	20.17 ± 0.75	174.72 ± 8.75	69.06 ± 10.9	22.56 ± 2.57
Group 2 (n=27)	20.04 ± 0.88	175.12 ± 9.16	69.68 ± 15.46	22.53 ± 3.58

The parameters are given as means ±SD; D - dominant limb; ND -non-dominant limb

Subjects in both groups initially attended a walking and running test. Following that, members of Group 1 performed a set of 6 resistance exercises in a semi-squat position intended to activate the hip abductors and external rotators, involving external rotation, frontal abduction, diagonal abduction to the front and back, lateral walking, and walking forwards and backwards.

External resistance was provided by rubber mini bands (TheraBand™, The Hygenic Corporation, Akron, OH) placed around the subjects' lower limbs just above the femoral epicondyles. Red bands (medium resistance) were used. This type of bands had also been used in studies by other authors (Gooyers, Beach, Frost, & Callaghan, 2012; Foley, Bulbrook, Button, & Holmes, 2017).

The participants were instructed to perform each exercise over a constant range of motion and with a constant rhythm allowing for unrestricted movement and controlled tensioning of the rubber without a risk of losing one's balance. This methodology was considered practicable because similar instructions are given to participants in sports practice or physiotherapy sessions by their therapists or coaches. The constant position and degree of stretching of the bands were monitored during the exercises in order to increase the probability of maintaining the same degree of resistance. Each exercise was carried out as three series of 10 repetitions. After performing the set of exercises and completing a 5-minute break, the subjects had their walking and running gait re-assessed. Participants in Group 2 performed the same set of exercises but without external resistance.

Walking and running gait parameters were assessed while the participants were using an H/P Cosmos Mercury Med. mechanical treadmill with Zebris FDM-T treadmill system software (Zebris Medical GmbH, Germany). Available publications indicate that this device may be regarded as an objective method for assessing walking and running gait (Navratilova, Krobot, Otruba, Nevrly, Krahulik, Kolar, Kolarova, Kaiserova, Mensikova, Vastik, Kurcova, & Kanovsky, 2020; Suciu, Onofrei, Totorean, Suciu, & Amaricai, 2016; Alsenoy, Thomson, Burnett, 2019). The analytical data were walking and running gait parameters generated from the WinFDM software report: step and stride length (cm), step width (cm), step and stride time (s), cadence (steps/min.), and force (N) and pressure (N/cm2) of the forefoot, mid-foot and heel. The walking gait examination was conducted at a constant velocity of 5km/h, and the running gait examination was conducted at a constant velocity of 10km/h. Each test attempt took 30 seconds to complete, with the subject having been walking or running for some time so that they had become accustomed to the speed before the actual recording began.

Statistica 13.1 was used for the statistical analysis. Descriptive statistics were used and the Kolmogorov-Smirnov test was employed to test for normality of a distribution. As this condition was not fulfilled, Wilcoxon's non-parametric pair-rank test was used to assess therapy outcomes within the groups and the Mann-Whitney U test was used for between-group comparisons, which were performed in a pair-wise fashion. The threshold for significance was set at $p<0.05$.

Results

The experimental group, which performed exercises while wearing resistance bands, registered significant changes in step length and width during the examination of walking gait. Step length of the dominant limb increased ($p<0.05$) and so did step width ($p<0.005$). There were also changes in foot pressure on the ground, with a decrease in maximum heel pressure in the non-dominant limb ($p<0.05$) and an increase in maximum forefoot pressure force in both limbs and heel pressure force of the non-dominant limb ($p<0.005$). The detailed results are presented in Table 2 and 3.

Walking gait examination in the control group revealed increased step width ($p<0.005$) and decreased maximum heel pressure on the ground in both limbs ($p<0.005$).

The examination of running gait revealed significant changes in the experimental group, with an increase in step length in the dominant limb ($p<0.05$) and stride length ($p<0.05$). Temporal parameters also changed. Increases were noted not only in step time in the dominant limb ($p<0.05$), but also in stride time ($p<0.05$) and, consequently, cadence ($p<0.05$). Foot pressure on the ground also changed, with decreased heel pressure in both the dominant ($p<0.05$) and non-dominant limb ($p<0.05$). Maximum heel pressure force of the non-dominant limb also decreased ($p<0.05$).

In the control group, the only change registered during the running gait examination concerned foot pressure force on the ground, with increases in mid-foot pressure force in both limbs ($p<0.05$). The detailed results are presented in Table 2 and 3.

Table 2. Temporal and spatial walking and running gait parameters of experimental and control group

	Parameter	Gait			Running		
		Before therapy	After therapy	*p*	Before therapy	After therapy	*p*
Group 1 (n=29)	Step length D,cm	69.0 ± 2.24	69.39 ± 2.45	0.256	97.06 ± 5.32	98.62 ± 4.87	**0.033**
	Step length ND, cm	68.47 ± 2.76	69.39 ± 2.93	**0.041**	96.86 ± 4.77	97.95 ± 4.69	0.074
	Stride length, cm	137.48 ± 4.67	138.42 ± 5.09	0.108	193.92 ± 9.82	196.57 ± 9.28	**0.033**
	Stride width, cm	8.66 ± 2.56	9.63 ± 2.86	**0.001**	6.69 ± 2.59	6.84 ± 2.46	0.786
	Step time D, sec	0.49 ± 0.01	0.49 ± 0.01	0.198	0.35 ± 0.01	0.35 ± 0.01	**0.026**
	Step time ND, sec	0.49 ± 0.01	0.49 ± 0.01	0.187	0.35 ± 0.01	0.35 ± 0.02	0.058
	Stride time, sec	0.99 ± 0.03	0.99 ± 0.03	0.158	0.71 ± 0.03	0.71 ± 0.03	**0.046**
	Cadence, steps/min	121.31 ± 4.10	120.61 ± 4.47	0.168	169.04 ± 8.75	167.33 ± 9.23	**0.049**
Group 2 (n=25)	Step length D,cm	69.56 ± 3.89	69.43 ± 3.61	0.581	98.93 ± 5.96	99.23 ± 5.92	0.977
	Step length ND, cm	69.03 ± 3.57	68.92 ± 3.29	0.777	98.25 ± 5.67	98.05 ± 5.61	0.273
	Stride length, cm	138.6 ± 7.35	138.36 ± 6.74	0.689	197.18 ± 11.40	197.28 ± 11.27	0.699
	Stride width, cm	8.29 ± 2.73	9.18 ± 3.11	**0.004**	6.71 ± 2.49	7.29 ± 2.64	0.063
	Step time D, sec	0.49 ± 0.02	0.49 ± 0.02	0.492	0.35 ± 0.02	0.35 ± 0.02	0.909
	Step time ND, sec	0.49 ± 0.02	0.49 ± 0.02	0.819	0.35 ± 0.02	0.35 ± 0.02	0.542
	Stride time, sec	0.99 ± 0.05	0.99 ± 0.04	0.599	0.71 ± 0.04	0.714 ± 0.04	0.753
	Cadence, steps/min	120.61 ± 6.08	120.796 ± 5.75	0.617	168.67 ± 9.86	168.65 ± 9.98	0.784

The parameters are given as means ±SD; D - dominant limb; ND -non-dominant limb

Table 3. Foot pressures and forces acting during walking and running in experimental and control group

	Parameter	Gait			Running		
		Before therapy	After therapy	*p*	Before therapy	After therapy	*p*
Group 1 (n=29)	Maximum pressure Forefoot D, N/cm^2	28.47 ± 4.62	28.57 ± 4.53	0.922	37.67 ± 7.25	37.68 ± 8.23	0.626
	Maximum pressure Forefoot ND, N/cm^2	29.00 ± 4.22	29.31 ± 4.76	0.411	36.99 ± 5.86	38.19 ± 6.83	0.074
	Maximum pressure Midfoot D, N/cm^2	13.21 ± 3.08	12.92 ± 3.04	0.144	20.72 ± 8.74	20.45 ± 6.92	0.888
	Maximum pressure Midfoot ND, N/cm^2	13.19 ± 3.54	13.10 ± 3.27	0.871	21.58 ± 8.55	21.73 ± 8.14	0.537
	Maximum pressure Heel D, N/cm^2	30.54 ± 4.28	29.94 ± 4.27	**0.038**	28.03 ± 14.22	25.12 ± 14.94	**0.028**
	Maximum pressure Heel ND, N/cm^2	30.91 ± 4.83	30.90 ± 4.43	0.770	29.49 ± 13.60	25.59 ± 14.74	**0.014**
	Maximum force Forefoot D, N	613.38 ± 92.16	629.35 ± 94.08	**0.0004**	893 ± 138.53	915.08 ± 138.27	0.247
	Maximum force Forefoot ND, N	611.04 ± 89.41	627.47 ± 93.74	**0.0002**	867.19 ± 149.20	893.21 ± 136.52	0.183
	Maximum force Midfoot D, N	133.17 ± 54.12	130.69 ± 52.29	0.183	304.07 ± 124.91	287.21 ± 102.26	0.304
	Maximum force Midfoot ND, N	128.69 ± 7.74	126.27 ± 49.38	0.516	327.41 ±149.75	308.61 ± 123.47	0.509
	Maximum force Heel D, N	433.40 ± 63.63	435.97 ± 57.69	0.362	434.13 ± 195.02	387.18 ± 195.23	0.067
	Maximum force Heel ND, N	438.77 ± 69.38	447.35 ± 68.48	**0.003**	446.64 ± 197.68	394.64 ± 195.6	**0.033**
Group 2 (n=25)	Maximum pressure Forefoot D, N/cm^2	30.48 ± 5.24	30.72 ± 5.33	0.590	44.05 ± 9.25	42.93 ± 10.20	0.353
	Maximum pressure Forefoot ND, N/cm^2	30.48 ± 5.39	30.18 ± 4.88	0.353	40.8956 ± 6.87	39.75 ± 7.48	0.103
	Maximum pressure Midfoot D, N/cm^2	13.18 ± 3.76	13.05 ± 3.71	0.840	24.0532 ± 8.84	25.54 ± 10.44	0.317
	Maximum pressure Midfoot ND, N/cm^2	13.16 ± 3.64	13.27 ± 3.97	0.427	23.2356 ± 7.74	23.81 ± 8.22	0.153
	Maximum pressure Heel D, N/cm^2	32.2784 ± 5.26	31.14 ± 4.75	**0.002**	21.4501 ± 15.26	22.66 ± 14.90	0.931
	Maximum pressure Heel ND, N/cm^2	32.54 ± 4.76	31.15 ± 4.32	**0.004**	21.772 ± 15.00	22.95 ± 14.68	0.241
	Maximum force Forefoot D, N	621.45 ± 114.35	626.03 ± 109.47	0.367	895.3 ± 166.3	875.49 ± 140.85	0.345
	Maximum force Forefoot ND, N	610.98 ± 110.72	614.70 ± 107.19	0.529	881.41 ± 181.42	878.67 ± 153.17	0.977
	Maximum force Midfoot D, N	137.52 ± 57.05	135.37 ± 60.94	0.527	286.73 ± 126.33	329.35 ± 157.62	**0.024**
	Maximum force Midfoot ND, N	123.7 ± 42.63	123.3 ± 43.12	0.637	288.64 ± 116.56	323.19 ± 130.25	**0.007**
	Maximum force Heel D, N	426.9 ± 86.48	422.5 ± 76.64	0.146	323.56 ± 227.61	352.78 ± 234.53	0.475
	Maximum force Heel ND, N	436.34 ± 86.48	430.89 ± 83.6	0.076	326.5 ± 240.42	345.29 ± 241.93	0.086

The parameters are given as means ±SD; D - dominant limb; ND -non-dominant limb

Discussion

We are not aware of any other publications that assessed the impact of exercises to activate the hip joint abductors and external rotators on walking and running gait parameters. Our results indicate that a single session of exercises intended to activate the hip joint abductors and external rotators did not influence gait parameters as assessed during treadmill-based testing.

The available literature confirms a key role of the hip joint abductors and rotators during pelvic motions in gait and running gait. For example, Chang et al. assessed lumbo-pelvic-hip muscle complex activity and kinematics during treadmill walking before and after exercises intended to induce fatigue in health individuals (Chang, Slater, Corbett, Hart, & Hertel, 2017). Fatigue was not shown to influence the activity of the gluteus medius, but there was reduced trunk rotation and reduced range of internal hip rotation during the loading phase. The authors concluded that the changes observed following exercise resembled a pattern typically seen in individuals with back pain (Chang, Slater, Corbett, Hart, & Hertel, 2017).

The present results indicate that the use of resistance exercises for the hip abductors and external rotators exerted an effect on running gait parameters. The experimental group registered increased step length and time for the dominant limb. These changes in turn produced increased stride length and time and reduced cadence. These results may indicate that activation of the hip joint abductors and external rotators with resistance band-supported exercise improves running economy.

A literature review by Semciw et al. appears to assign a key role in running gait to the gluteus medius, with the highest levels of activity exhibited in the initial stance phase (Semciw, Neateb, & Pizzari, 2016). It also notes that activation of this muscle is impaired in individuals with Achilles tendinopathy and patellofemoral pain syndrome, leading to impaired positional control of the pelvis in the frontal plane.

Studies by Bartlett et al. and Chumanov et al. showed that gluteal muscle activity increased with increasing running velocity (Bartlett, Sumner, Ellis, & Kram, 2014; Chumanov, Wille, Michalski, & Heiderscheit, 2012). Importantly, however, Bartletta et al., who assessed gluteal muscle activity during walking, running, sprinting and climbing a ladder, did not report significant changes in the increase in EMG signal amplitude between walking and running (Bartlett, Sumner, Ellis, & Kram, 2014). Significant changes in gluteus medius activity were only observed after the running speed changed. These results may explain our finding of a greater number of changes in parameters during running than walking.

There is an abundance of studies assessing the activity of the hip abductors during common types of exercise, including both exercises without external resistance and with resistance bands placed at various levels along the lower limbs (Distefano, Blackburn, Marshall, & Padua, 2009; Youdas, Adams, Bertucci, Brooks, Steiner & Hollman, 2015; McBeth, Earl-Boehm, Cobb, & Huddleston, 2012; Bishop, Greenstein, Etnoyer-Slaski, Sterling, & Topp, 2018; Berry, Lee, Foley, Lewis, 2015; Cambridge, Sidorkewicz, Ikeda & McGill, 2012).

Studies have also addressed the impact of resistance banding during exercise on lower limb kinematics. Gooyers et al. investigated the effect of placement of rubber bands in the distal thigh on the position of the knee joint during body-weight squat and vertical jumping (Gooyers, Beach, Frost, & Callaghan, 2012). They concluded that rubber bands were not effective in improving knee valgus. They stressed, however, that their findings could have been influenced by the fact that the sample was made up of physically active people, who may have learnt the correct techniques for performing these exercises.

Consequently, in another study Foley et al. assessed the effect of placing resistance bands in the distal thigh on lower limb biomechanics in both trained and untrained individuals (Foley, Bulbrook, Button, & Holmes, 2017). Muscle activity and lower limb kinematics were assessed during squatting performed without an external load and with a barbell. Attempts were performed without rubber bands and with medium-resistance red Thera bands (The Hygenic Corporation, OH, USA) on, as in the present study. The bands were placed around the distal thigh, just above the femoral epicondyles. The authors observed that banded squatting enhanced activation of lower limb muscles but did not alter knee joint biomechanics. The results did not depend on the level of physical fitness or the presence vs absence of non-body-weight load in the form of a barbell. The authors concluded that there was no evidence to suggest that the use of resistance bands for the hip joint abductors and external rotators during a single session of barbell squatting offered sufficient protection against aggravating knee valgus.

Furthermore, the findings of yet another study indicate that the use of resistance bands during barbell squatting increases knee valgus and may thus make the individual more prone to injury. Reece et al. assessed kinematic and EMG parameters during squats with a barbell whose weight corresponded to 40% and 80% of 1RM (Reece, Arnold, Nasir, Wang, & Abboud, 2020). The bands used were low- and high-resistance and were placed just above the knee joints, as in our study and the works of Gooyers and Foley (Gooyers, Beach, Frost, & Callaghan, 2012; Foley, Bulbrook, Button, & Holmes, 2017). The study revealed that both low- and high-resistance bands increased knee valgus angles. The authors concluded that the prevalent view among clinicians and coaches that resistance bands support neutral knee positioning during squatting was erroneous, and recommended avoiding this strategy. At the same time, they stressed that further research should address the long-term effects of the use of resistance bands.

Our study of a group of healthy individuals revealed a greater impact of activation of the hip abductors and external rotators on gait parameters during walking than during running. These findings may thus suggest that exercises intended to increase the involvement of the gluteal muscles induce changes in lower limb parameters during tasks requiring more dynamic performance and, consequently, greater muscle activation, in healthy individuals. Dai et al. observed beneficial effects of using resistance bands for the hip abductors on lower limb biomechanics during bipedal jumping (Dai, Heinbaugh, Ning, & Zhu, 2014). They conducted a study using the Vicon motion analysis system with a dynamometric platform and EMG measurements among 13 males and 15 females aged about 21 years. The subjects performed a task consisting in jumping down from a step onto a dynamometric platform and jumping up again (jump-landing-jump task). This task was performed twice with and without resistance bands, which would be placed above the ankle joints to oppose hip joint abduction. Analysis showed a higher mean torque of the hip abductors and greater bilateral activity of the gluteus medius just before and just after the landing in trials with resistance bands on. The use of resistance bands for the hip joint abductors exerted a beneficial effect on angular positions of the hip and knee joints. Accordingly, the authors recommended using this strategy while learning the correct technique of jumping and landing (Dai, Heinbaugh, Ning, & Zhu, 2014).

Parr et al. conducted a study that was methodologically similar to the present one (Parr, Price, & Cleather, 2017). Their study enrolled 17 male rugby players to evaluate the effect of a warm-up including exercises to activate the gluteal muscles on the activity of these muscles while the subjects performed the high hang pull, a dynamic task with external resistance. The subjects warmed up according to a protocol designed by the authors of the study and then performed 3 attempts at the barbell exercise, with the barbell weight corresponding to 80% of their 1RM at the time. Following 20-minute rest, they repeated the warm-up protocol, which, however, now also included exercises to activate the gluteal muscles. Analysis of EMG data revealed an effect of gluteal activation during the warm-up manifesting as lower mean peak activity of the gluteus maximus muscles. No significant changes were reported for the remaining parameters, but there was a trend towards increasing bilateral strength of the gluteus medius and maximus, biceps femori, and the hamstrings. The authors believe that their results indicate a beneficial effect of an appropriate warm-up on facilitating gluteal muscle activation by improving their strength and reducing the need for neural stimulation. This may lead to improving the quality of motion during the following exercise session proper (Parr, Price, & Cleather, 2017).

There are certain limitations to our study. It is possible that the prescribed set and intensity of exercises did not sufficiently influence the activity of the gluteal muscles. The study used a treadmill, which allowed for maintaining constant walking and running velocities, but a treadmill-based exercise may substantially influence walking and running parameters compared to walking/running on a stable surface.

Conclusion

1. A single session of resistance band-supported exercises to activate the hip joint abductors and external rotators did not influence gait parameters in healthy individuals.
2. Activation of the hip joint abductors and external rotators with resistance band-supported exercises may improve running economy.
3. The present results encourage further research on the effect of exercises to activate the hip joint abductors and external rotators on walking and running gait parameters utilizing other assessment methods.

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