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Impact of Medicine Ball Training on Amplitude of Electromyography Activity in Back Pain Patients During Gait

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Abstract

Background: This research aimed to assess the effect of medicine ball exercise on the amplitude of electromyography activity in back pain patients while walking.

Methods: Twenty back pain patients participated in this research. The participants were divided into two intervention (age: 26.4±2.00 years) and control (age: 28.8±2.0 years) groups. The intervention involved training with medicine ball. The Roland Morris questionnaire was employed to measure the pain index**.** In addition, the participants walked at self-selected gait speed along an 18-m level walkway. During walking, muscle activities of the following muscles were recorded: gastrocnemius lateral (GAS-L), biceps femoris (BF), Semimembranosus muscle (SM), gluteus medius (GM), Erector spinae right (ES-R), Erector spinae left (ES-L), Internal abdominal oblique (IA-O) and External abdominal oblique (EA-O).

Results: Significant main effects of "Time" for disability index were observed ($P<001$). Also, significantly lower disability index was observed after exercise with medicine ball compared with pre-intervention. Significant main effects of "Time" for BF ($P<001$, $\eta^2=0.532$) and ES-R ($P<001$, $\eta^2=0.449$) muscles activities during midstance phase were also found. The findings demonstrated lower BF activities after exercise with medicine ball compared to before it. Finally, greater ES-R activities post-exercise were observed with medicine ball compared with before it.

Conclusion: This study revealed that exercise with medicine ball improved disability index and muscle activities in individuals with back pain while walking.

Keywords: Walking, Electromyography, Pain

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Introduction

Low back pain (LBP) has a global prevalence of 6.8% (1), occurring in 19.6% of adults (2). People with LBP demonstrate earlier fatigue in trunk muscles (1, 3, 4). A study reported that patients with back pain do not have the ability to voluntarily recruit the muscular median frequency (5). Many studies have reported conflicting findings regarding muscular activity in LBP subjects (6-9). In a previous research, (10) used EMG to demonstrate that the lumbar paraspinal muscles are minimally active in relaxed standing.

Williams (1965) (11) recommended exercises to strengthen the abdominal muscles, while Cyriax (1976) (12) focused more on keeping the lumbar lordosis to manage persistent pain. Other physical methods and behavioral strategies should also be taken into account to properly treat the combination of symptoms, especially when pain is a major factor (12). Researchers have researched the trunk muscles extensively using different methods to understand how these muscles malfunction. Surface EMG has been a suitable system for how trunk muscles work along certain movements and positions (3).

Meanwhile, rehabilitation is recommended as a key point for treatment of LBP (13). Sport activity that focus on strengthening the trunk and back muscles while improving body coordination may help individuals with chronic back pain recover more effectively (14, 15). In spite of massive research, the root causes of LBP. Resistance training can help improve key fitness markers such as muscle strength, explosive power, and endurance (16). The real advantage of these exercises is that they engage far more muscles and establish greater muscle activation compared to traditional strength exercises. Research by Wilk et al suggested use of unstable surfaces such as a medicine ball for similar movements along advanced recovery stages to maximize benefits (17).

The author argues this is because these exercises force the body into movements that require far greater dynamic stability (18). For example, Norian et al demonstrated that rehabilitation with medicine ball improved knee co-contraction in LBP subjects during gait (19). Research on medicine ball exercises has examined how upper and lower body strength as well as power relate to overall explosive force during throws (20). However, there is still limited evidence backing their effectiveness. Existing studies are narrow in scope—often due to small sample sizes—and fail to measure critical factors such as muscle activity (EMG) in individuals with back pain, which could help predict injury risks.

There is no available study that has specifically investigated how medicine ball exercises affect individuals with lower back pain. Thus, this study aimed to ascertain the effect of medicine ball training on amplitude of electromyography activity in those with LBP during walking. We hypothesized that pain index in individuals with LBP would be smaller after exercise with medicine ball. We also hypothesized that muscle activities in individuals with LBP would diminish after exercise with medicine ball (21, 22).

Methods

Participants

Twenty LBP patients volunteered to participate in the present study. They were divided into two intervention (age: 26.4 ± 2.05 years, mass: 74.08 ± 3.06 kg, height: 181 ± 7.04 cm) and control (age: 28.8 ± 2.05 years, mass: 88.45 ± 3.01 kg, height: 181 ± 7.01cm). The exclusion criteria included underlying pain of trauma, nerve or spinal cord injury in the lumbar spine, disc herniation, rheumatic disease, inflammation, previous lumbar surgery, pregnancy, as well as cardiorespiratory and metabolic diseases. Patients with LBP were included in the study after signing the consent form. The intervention group performed resistance exercises with medicine ball while the control group participated in pre-test and post-test only.

Pain and muscle activity assessment

The Roland Morris Questionnaire was employed to measure the quantity of pain (23). To record the reaction forces of the ground during walking before and after the training, the Bertec Force Plates (USA) with a sampling frequency of 1000 Hz was utilized to record kinetic data.

A frequency cut-off of 20 Hz was applied to filter the reaction forces of the ground. The peak reaction forces and the time to reach the peak forces were extracted according to the study by Jafarnezhadgero et al (24).

An EMG system (Biometrics, UK, sample rate: 1000 Hz) with surface electrodes was empoyed to record EMG of the gastrocnemius lateral (GAS-L), biceps femoris (BF), semimembranosus muscle (SM), gluteus medius (GM), erector spinae right (ES-R), erector spinae left (ES-L), internal abdominal oblique (IA-O), and external abdominal oblique (EA-O). Thereafter, the skin was abraded prior to electrode placement (25). For EMG analyses, the gait cycle included loading phase, the mid-stance, and push off phases (26). The maximum voluntary isometric contraction (MVIC) was recorded EMG data normalization (27).

Exercise program

The training was performed for three sessions each week on nonconsecutive days (30-32) (Table 1).

Statistical analyses

The normality of data was affirmed through the Shapiro-Wilk test. A mixed ANOVA with repeated measures was employed for analysis using SPSS 26.

Results

Anthropometric characteristics of two groups are reported in Table 2.

Significant time effects for SM activity during loading were observed ($P < .001$, $\eta^2 = 0.517$). Lower SM muscle activity was found after exercise with medicine ball compared with pre-exercise.

Significant time effects were observed for BF ($P < .001$, $\eta^2 = 0.532$) and ES-R ($P < .001$, $\eta^2 = 0.449$) muscle activity along the midstance phase. Lower BF activity was reported post-exercise with medicine ball. Also, greater ES-R muscle activity after exercise with medicine ball compared with pre-exercise was reported (Table 3).

Effects of "Group" for ES-L was significant ($P = 0.023$, $\eta^2 = 0.255$). Muscle activity during the midstance phase. Greater ES-L activity in the intervention than in the control group was reported (Table 3).

Group effects for ES-R ($P = 0.003$, $\eta^2 = 0.394$) and EA-O ($P = 0.006$, $\eta^2 = 0.350$) activities during the midstance phase was significant. Greater ES-R and EA-O activities in the intervention than in the control group was observed (Table 3).

Group-by-Time interactions were significant for IA-O muscle activity during loading phase ($P = 0.005$, $\eta^2 = 0.089$). Post hoc analysis demonstrated significantly greater IA-O muscle activity in the in the intervention group after exercise with medicine ball compared with pre-exercise (Table 3).

Group-by-Time interactions were significant for ES-R activities during midstance phase ($P = 0.012$, $\eta^2 = 0.300$). Post hoc analysis demonstrated greater ES-R activity in the intervention group after exercise with medicine ball compared pre-exercise (Table 3).

Discussion

This study was the first to explore the influence of medicine ball training on the amplitude of electromyography

Table 1. Exercise program with medicine ball

Week	Sections of each session	Intensity (Vo_2Max %)	Section time in each session (minutes)
Weeks 1: (three sessions per week)	Warm-up	50	10
	Specific isometric and isotonic exercises for the lower body and upper body	50	40
	Cooldown	50	10
Weeks 2: (three sessions per week)	Warm-up	50	10
	Specific isometric and isotonic exercises for the lower body and upper body	50	40
	Cooldown	50	10
Weeks 3: (three sessions per week)	Warm-up	55	10
	Specific isometric and isotonic exercises for the lower body and upper body	55	40
	Cooldown	55	10
Weeks 4: (three sessions per week)	Warm-up	60	10
	Specific isometric and isotonic exercises for the lower body and upper body	65-70	40
	Cooldown	60	10

Warm-up: Jogging, dynamic stretching movements
Main section: isotonic and iosmetric as well as cyclic training with beta medicine ball.
Cooldown: Local endurance and relaxing the muscles, static stretching

Table 2. Group-specific baseline values of all reported anthropometrics together (M ± SD).

Parameter	Intervention group	Control group	Sig.
Age (years)	28.8 ± 2.5	26.4 ± 2.5	0.119
Body height (cm)	1.81 ± 7.1	1.81 ± 7.4	0.964
Body mass (kg)	88.45 ± 3.1	74.08 ± 3.6	0.208

Note. M, mean; SD, standard deviation; Sig, Significant

activity in back pain patients during gait.

The results demonstrated significantly lower SM muscle activity after exercise with medicine ball compared with pre-exercise. The results revealed significantly lower BF muscle activities post-exercise with medicine ball compared with pre-exercise. The hamstrings play a key role in stabilizing the knee joint and are necessary for maintaining dynamic control of the knee joint. Meanwhile, men tend to have higher levels of active and passive hamstring stiffness than women, which may help explain why knee-joint injuries are more frequently observed in female athletes (28). The attachment of the hamstring muscles to upper limbs suggested that active stiffness in this muscles might affect pelvic and core stability; nonetheless, the relationship is currently speculative and unsubstantiated (29).

The roles of hamstring muscles to these observed deteriorations are greater in individuals with LBP (30). When showed individuals with LBP is necessary to consider muscles and joints in the core muscles (31). Muscle groups surrounding the lower limb have been reported to have similar fatiguing patterns in individuals with LBP (32).

It is believed that LBP is associated during walking, increased trunk stiffness, higher activation of the erector spinae (33) and the hamstring muscles (29). The result of this study suggests a clinically important effect on hamstring function which occurs after exercise with medicine ball in patients with a history of LBP. This change may be indicative of a delayed muscle response to the resistance training.

The finding demonstrated greater EA-O activities in the intervention group than in the control group. Exercises performed in different positions required similar levels of extensor muscle activation but differed in flexor muscle recruitment patterns, with the oblique muscles presenting greater engagement compared to the rectus abdominis. The oblique muscles and rectus abdominis work simultaneously to stabilize pelvic positioning, while the multifidus acts as the antagonist muscle along these movements (34).

Musculoskeletal pain leads to reduction of IA-O activity while the muscle as an agonist (35). Pain could result in compensatory actions from other muscles (36). Group-by-Time interactions for IA-O activities at loading were significant. Greater IA-O activities were observed in the intervention group after exercise with medicine ball compared with per-exercise. These results are in accordance with previous studies confirming a reduction of activation in the right multifidus, iliocostalis, and abdominal muscles in LBP individuals during walking (37, 38). In comparison to other studies, where other resistance programs were used in individuals with LBP, it is difficult to generalize the conclusions from other resistance programs to the patients' population.

Several limitations should be noted. First, the small sample size limited our ability to detect smaller effects that might have reached statistical significance in a larger sample size. Further, the study exclusively included male participants, so we cannot generalize the results to the group of men and women. Also, in this study, the activity of some other muscles of the lower and upper limbs was not recorded owing to the limitations of installing the electrodes, which should be examined in future studies. Also, lack of registration of kinematic variables was another limitation of the present study.

Table 3. Muscle activity (% maximum voluntary isometric contraction [MVIC]) at the loading, midstance and push off phases along walking

		Intervention group		Control group		SIG (Eta)		
Muscle activity		**PRE**	**POST**	**PRE**	**POST**	**Time**	**group**	**Time*group**
GAS LAT	L	12.14±9.56	11.60±5.20	12.64±13.34	15.85±17.38	0.746 (0.006)	0.526 (0.023)	0.649 (0.012)
	MS	16.32±17.33	24.3±12.60	19.17±18.44	34.74±24.40	0.116(0.132)	0.166(0.104)	0.290(0.062)
	PO	9.80±4.21	10.82±6.95	6.36±3.11	10.16±10.1	0.273(0.066)	0.342(0.050)	0.523(0.023)
BF	L	7.57±3.93	9.1±7.79	10.82±6.95	13.89±17.36	0.525(0.23)	0.198(0.090)	0.817(0.003)
	MS	30.65±19.18	10.41±7.52	45.19±32.37	10.40±7.26	**<.001(0.532)**	0.261(0.070)	0.247(0.074)
	PO	12.81±9.47	18.55±16.93	9.65±7.68	7.23±2.93	0.575(0.018)	0.067(0.175)	0.178(0.098)
SM	L	36.50±24.94	16.42±11.32	39.11±27.13	9.81±7.35	**<.001(0.517)**	0.776(0.005)	0.437(0.036)
	MS	20.61±10.56	18.20±13.70	18.19±13.29	15.89±16.69	0.636(0.013)	0.532(0.022)	0.991(0.000)
	PO	7.57±3.93	15.52±12.30	10.82±6.95	9.80±6.98	0.164(0.105)	0.658(0.011)	0.077(0.164)
GLUT MED	L	15.12±14.40	17.12±12.63	7.98±5.87	8.27±6.77	0.792(0.004)	0.055(0.200	0.843(0.002)
	MS	15.61±13.05	15.50±13.85	13.07±9.38	9.44±7.5	0.584(0.017)	0.262(0.069)	0.607(0.015)
	PO	54.87±23.47	18.15±12.87	54.62±27.10	10.60±1.62	**<.001(0.726)**	0.291(0.062)	0.337(0.051)
ES-R	L	10.33±1.80	14.36±8.50	16.24±16.83	8.16±5.70	0.511(0.26)	0.968(0.000)	0.061(0.192)
	MS	7.60±2.74	25.36±14.63	6.34±4.55	9.18±5.63	**0.001(0.449)**	**0.003(0.394)**	**0.012(0.300)**
	PO	25.75±15.35	20.25±13.26	21.71±11.25	20.56±15.64	0.527(0.023)	0.618(0.014)	0.678(0.010)
ES-L	L	32.22±92.58	17.19±16.64	8.63±6.15	13.5±12.66	0.329(0.053)	**0.023(0.255)**	0.084(0.157)
	MS	26.80±22.67	14.35±12.99	21.62±15.56	13.95±7.80	0.096(0.146)	0.500(0.026)	0.682(0.010)
	PO	16.70±13.35	13.35±11.46	21.44±24.67	12.24±9.54	0.251(0.073)	0.707(0.008)	0.586(0.017)
IA-O	L	14.88±15.38	19.21±15.61	18.82.±17.96	19.80±13.84	0.642 (0.012)	0.702(0.008)	**0.005(0.089)**
	MS	17.72±11.1	22.8±12.38	15.28±13.15	11.84±6.58	0.875(0.001)	0.134(0.120)	0.190(0.093)
	PO	21.59±16.77	13.19±10.75	19.32±12.9	21.57±24.20	0.605(0.015)	0.526(0.023)	0.374(0.044)
EA-O	L	20.41±22.44	15.51±18.18	17.49±17.86	11.41±12.86	0.372(0.044)	0.529(0.022)	0.923(0.001)
	MS	34.69±23.71	17.31±11.42	13.15±5.61	15.12±10.52	0.157(0.108)	**0.006(0.350)**	0.080(0.160)
	PO	38.47±28.18	10.96±5.22	36.88±25.50	10.95±5.22	0.048(0.200)	0.967(0.000)	0.873(0.001)

Note. GAS LAT, Gastrocnemius lateral; BF, Biceps femoris; SM, Semimembranosus: GM, Gluteus medius: ES-R, Erector spinae right; ES-L, Erector spinae left; IA-O, Internal abdominal oblique; EA-O, External abdominal oblique
Bold number dimonstrit significant difference

Conclusion

This study revealed that exercise with medicine ball improve disability index and muscle activities in individuals with back pain during walking.

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Ethical Approval

The study was conducted in accordance with the latest version of the Declaration of Helsinki. Ethical approval was obtained from the local ethical committee (IR.ARUMS.REC.1397.031).

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