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Effects of low-frequency vibration to the back muscles on recovery-related parameters in college football athletes: a preliminary study

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KEYWORDS
Low-frequency vibration; Lower back muscles; Fatigue; Randomized controlled trial.

ABSTRACT
Muscle fatigue is commonly found in football athletes due to high training or competitive intensity. Although vibration therapy is one of the popular methods that can transfer mechanical energy into the target muscles, only little evidence on the effects of low-frequency vibration therapy (LFVT) on lower back muscles fatigue was available. Therefore, this study aimed to examine the immediate effects of LFVT on recovery of the lower back muscles after inducing fatigue. Fourteen football athletes of Shaoguan were randomly allocated to receive either a -4min session of the LFVT group or a control group (rested on a bed), after exercise-induced fatigue. Recovery-related parameters including sit-and-reach, pressure pain threshold, visual analog scales, and heart rate variability were obtained before the session of exercise, and immediately after receiving either LFVT or control. Results showed that the LFVT group had no significant difference in the lower back muscles› recovery compared to the control group after the intervention although some parameters did go in the better direction. We conclude that LFVT may have no immediate effects on exercise induced-muscle fatigue.

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Introduction

In order to get the ideal result in the football game, the players must exercise at high intensity during the training or competition; consequently, fatigue is commonly found during and after exercise and is inevitable. Muscle fatigue is used for describing the declining ability in physical performance for the present[1]. It is a long-standing observation that soccer players are often submitted to high-muscle actions during matches and training sessions. Fatigue after football training or competition is commonly found in football athletes. Besides that, football demands accelerations, decelerations, jumps, changes of direction, and technical and tactical skills to successfully adapt to a rapidly changing environment and achieve optimal performance[2]. Repetitive physical exercises at high intensity could lead to muscle fatigue because of the accumulation of lactic acid or depletion of chemical energy (ATP) in the muscles. It is a kind of stress.

Achieving a good balance between exercise or game stress and recovery is crucial to an athlete's performance; otherwise, it may bring about potential injuries or weakening abilities (poor judgment, reduced endurance, and acceleration) in the athletes[3]. To achieve this balance, many rehabilitation therapies have been used.

Vibration therapy is one of the popular methods that can transfer mechanical energy into the target muscles[4]. Vibration therapy can be divided into two patterns: whole-body vibration therapy and local vibration therapy. There is much less research on the use of local vibration[5,6] compared to whole-body vibration[7-9]. Several measures were involved to assess the effects of low-frequency vibration therapy (LFVT) on the recovery of the lower back muscles. However, the perception of muscle fatigue after exercise measured with the visual analog scale (VAS), and pressure pain threshold (PPT) are important measures to consider when studying the effects on recovery[10]. If the lower back muscles of participants had a poor recovery, they cannot provide good results on the sit-and-reach (SAR) because they cannot lean forward better. Among the tools proposed to assess the athlete's fatigue, the analysis of heart rate variability (HRV) provides an indirect evaluation of the settings of autonomic control of heart activity[11].

However, the effects of vibration therapy on lower back muscle fatigue seldom be explored especially in college football athletes because the back muscles are always used throughout the game as being the core muscles[12]. Therefore, this study aims to measure the effect of LFVT on physical and sensory recovery of back muscles for football players and compare the data within and between the LFVT group and control group.

Materials and methods

Design and setting

A randomized controlled trial was done in the Physical Therapy Department, Faculty of Physical Education School, Shaoguan University, China. The single-blinded trial was conducted by well-trained assessors. The research proposal of this study was approved by the Khon Kaen University Ethical Committee (HE642185).

Participants

Fourteen participants were enlisted through the notice boards; they were numbered by an independent researcher of this study and placed the number in an opaque sealed envelope, according to the website (http://www.randomization.com), the participants were randomly allocated into the LFVT group (n=7) or control group (n=7) using the random block sizes.

The inclusion criteria were those male football athletes, aged from 18 years old to 27 years old, having a football training history of more than one year. Each of them was excluded if he had one of the following conditions: chronic lower back pain that continues for 12 weeks or longer, a habit of smoking or drinking, a history of surgery in one year, took any medicine one week ago for the data collection[13].

Until now there is no relevant study about LFVT towards lower back muscles through the literature review. Therefore, we conducted this pilot study, using 14 participants as the recommendation for a pilot study (a minimum of 12 participants)[14].

Procedure

The 14 participants who met the inclusion criteria in this study were assigned randomly to either the control group or the experiment group (LFVT group).

There were two visits for each participant during the data collection. The first visit was getting familiar with the location, surroundings, and how to work with the assessors. The second visit for the participants was the day next to the first visit. Before the protocol, the participants in the two groups were done the baseline data collection (including height, weight, and age). Moreover, some relevant parameters were also collected including HRV (heart rate variability), PPT (pressure pain threshold), VAS (visual analog scales), and SAR (sit-and-reach). Then the participants in the two groups were induced to fatigue by performing a set of back exercises. They were in a prone position, two arms straightened over the head, then lifted up the arms and feet as high as possible and returned to the original prone position[13] (Figure 2). They received encouragement if their position of hands and feet was lowered to the horizontal level. Fatigue was confirmed when the participants cannot do this anymore or claimed that they were exhausted or discomfort[13]. After the induced fatigue, the participants in the LFVT group received 4-min vibration therapy and at the same time, the participants in the control group lay down quietly under the same circumstances. After the protocol, the participants in the two groups were re-assessed for all variables.

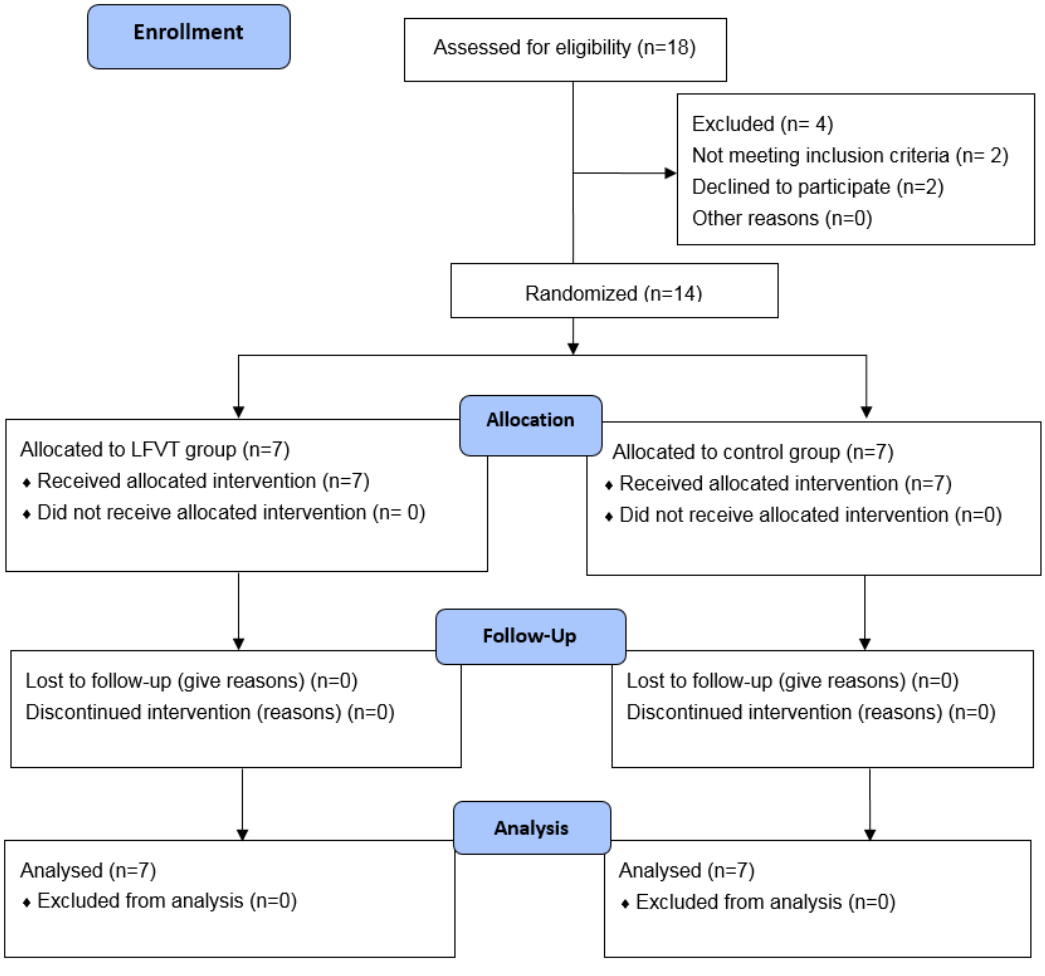

Figure 1 The participation flowchart.

Figure 2 The position for induced fatigue in this study.

Treatment

Experiment group (Low vibration group – LFVT group)

Each participant of the experimental group received the 4-min low-frequency vibration therapy between 16:00 and 18:00 on the data collection day according to the participants' time. The vibration therapy was applied using the vibration stick (TK AMC – 888, Infrared Massager, China), and the chosen frequency of this device was 8 Hz (the frequency was measured by the instrument Biopac, USA) (Figure 3) by a well-trained vibration therapist. The vibration therapy points were on the lower erector spinae muscles of the lower back (Figure 4).

Figure 3 The treatment instrument of this study.

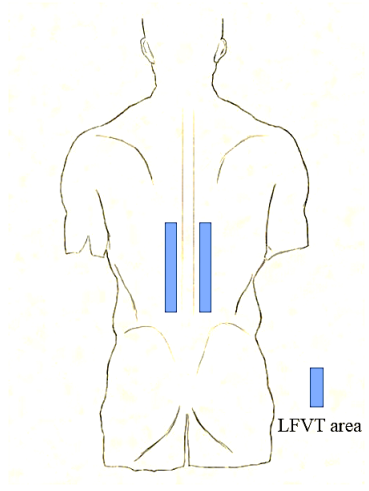

Figure 4 The treatment area of this study.

Control group

The participants in the control group relaxed for four minutes in a prone lying position quietly in the same surroundings as the treatment group.

When all the data collection was done, the participants in the control group were offered to receive the same vibration therapy as the participants in the LFVT group.

Outcome measures

All the parameters were collected before and after the programs of each group by four assessors. Every parameter was measured by the same assessor. Details of the assessments are as follows.

Visual analog scales

It is a subjective understanding measurement of pain perception. The VAS of this study was recorded on a discrete integer scale, marking categories ranging from 0 to 10 points. Zero means there is no pain whereas 10 represents the most severe pain. The participant draws a line across the given line. Then the distance from zero to the intersection is the pain score of the participant[14]. It is the main outcome of this study.

Sit-and-reach

This parameter was measured using a sit-and-reach device (Kedao TZCS-1, China). The participants removed the shoes and sat on a flat surface with legs extended in front of the body and the knee joints must be straight. Then the participants pushed forward the ruler as far as they could, and then the screen showed the maximum number of sit-and-reach in centimeters. The measurement procedure was repeated three times and taken the mean data for the analysis[16].

Heart rate variability

The heart rate variability was tested using an HRV device (uBioMacpa version 1.0, Korea). The participants fasted four hours before the data collection. They were not allowed to talk, use a smartphone or fall asleep during the testing protocol. The HRV device was connected to a laptop computer, providing real-time visual results[17].

Pressure pain threshold

This parameter was measured by the machine for measuring the PPT (Combo, OE-220, Japan). The number of the screen of the instrument increases as the pressure which is vertical towards the lower back muscle increases. The participant could press the button which was attached to the machine when he felt pain or uncomfortable in the pressing process, then the number of the screen stopped, this point is the pressure pain threshold. It was measured three times and taken the mean data for the analysis[18].

Statistical analysis

Data analysis was conducted by IBM SPSS Statistics version 26. Through the Kolmogorov-Smirnov examination, the data group age, height,

and weight showed normal distribution, while the PPT, SAR, VAS, and HRV were non-normal distribution. The baseline comparison between the two groups included age, height, weight, PPT, VAS, and HRV. Using Mann-Whitney U test examined the differences between pre-protocol and post-protocol in the experiment group and control group. The method of independent samples T-Test was used to examine the changes of post-intervention minus before intervention between the two groups. A *p*-value less than 0.05 was regarded as statistically significant.

Results

Baseline characteristics

The baseline characteristics of the participants are presented in table 1. Fourteen participants were recruited in this study. They were all male athletes (except the goalkeeper) in the university. The baseline of age, height weight, SAR, PPT, VAS, and HRV had no significant difference between the two groups.

Table 1 Comparison of the baseline characteristics between the groups (Independent T-test)

	Control	Vibration	*p*-value
Number of participants	7	7	
Age (year); mean (SD)	20.14 (0.6)	19.57 (1.1)	0.103
Height (cm); mean (SD)	169.85 (5.0)	72.14 (5.0)	0.814
Weight (kg); mean (SD)	56.71 (7.0)	62.42 (9.4)	0.493
HRV			
LF (ms^2)	7.54 (0.67)	7.70 (0.86)	0.111
HF (ms^2)	7.02 (1.09)	6.95 (0.69)	0.883
LF/HF	1.05 (0.11)	1.08 (0.12)	0.229
Mean BMP(t/m)	76.48 (16.64)	78.37 (14.45)	0.713
SDNN	52.92 (24.48)	52.18 (16.37)	0.887
RMSSD	50.00 (30.49)	43.22 (19.60)	0.657
Other parameters			
PPT (KG)	4.69 (1.43)	4.827 (1.83)	0.825
VAS(CM)	4.43 (1.39)	5.29 (1.11)	0.948
SAR (CM)	10.68 (4.949)	6.17 (4.874)	0.632

Note: LF, sympathetic activity; HF, para-sympathetic activity; LF/HF, LF divide HF; Mean BMP, average pulse; SDDN, pulse standard deviation; RMSSD, root mean square standard deviation; PPT, pressure pain threshold; VAS, visual analog scale; SAR, sit-and-reach.

Immediate effects of low-frequency vibration on heart rate variability

Table 2 shows the immediate effects after receiving the protocol in the two groups. There was no significant difference in both groups' baseline compared with the post-protocol values respectively, but some values did go towards the better direction (Table 2), for example, the value HF (para-sympathetic activity) (from 6.80 to 6.90), Mean BMP (mean pulse) (from 76.40 to 74.00) and RMSSD (root mean square standard deviation) (from 39.20 to 52.00 in the LFVT group. In the control group, such findings were not shown on the parameters HF (from 7.60 to 6.8). When it comes to the comparison of the changes which were between the baseline and post-test, the parameter LF (sympathetic activity) are slightly better (Table 3).

Immediate effects of low-frequency vibration on other parameters

There was no significant difference within and between group comparisons. We found that in the LFVT group, the median value of PPT increased after the vibration therapy, whereas the median value of PPT decreased after the 4-min rest in the control group (Table 2).

Table 2 Comparison between baseline (pre-test) and post-test in the vibration and control

Parameters	Control group (n = 7)			Vibration group (n = 7)		
	Baseline Median (IQR)	Post-test Median (IQR)	*p*-value	Baseline Median (IQR)	Post-test Median (IQR)	*p*-value
HRV						
LF (ms^2)	7.3 (1.48)	7.7 (0.98)	0.612	7.7 (1.3)	7.7 (1.08)	0.733
HF (ms^2)	7.6 (6.25)	6.8 (6.25)	0.933	6.8 (1.1)	6.9 (1.65)	0.310
LF/HF	1.0 (61.7)	1.1 (61.7)	0.414	1.0 (0.2)	1.2 (0.20)	0.914
Mean BMP(t/m)	75.8 (33.65)	64.1 (35.3)	0.063	76.4 (17.8)	74.0 (19.37)	0.866
SDNN	45.4 (32.35)	64.8 (36.95)	0.499	53.0 (27.8)	53.0 (29.30)	1.000
RMSSD	34.0 (28.80)	59.4 (35.17)	0.612	39.2 (27.9)	52.0 (33.9)	0.612
Other parameters						
PPT (KG)	4.42 (2.57)	3.63 (2.66)	0.091	3.91(3.49)	4.99 (2.98)	0.600
VAS(CM)	5.0 (1.93)	6.0 (1.78)	0.131	6.0 (1.0)	6.0 (3.00)	0.705
SAR (CM)	10.3 (8.93)	11.4 (7.77)	0.735	3.6 (9.0)	4.7 (8.88)	0.753

Note: LF, sympathetic activity; HF, para-sympathetic activity; LF/HF, LF divide HF; Mean BMP, average pulse; SDDN, pulse standard deviation; RMSSD, root mean square standard deviation; PPT, pressure pain threshold; VAS, visual analog scale; SAR, sit-and-reach.

Table 3 Comparison of mean about the changes which are post-intervention minus before intervention between the two groups (Independent T-Test)

Parameters	Control group (n = 7) Post minus before Mean (Standard deviation)	Vibration group (n = 7) Post minus before Mean (Standard deviation)	ES	*p*-value
HRV				
LF (ms^2)	0.18 (0.95)	-0.20 (1.08)	-0.373	0.494
HF (ms^2)	-0.04 (0.70)	-0.31 (0.70)	-0.385	0.486
LF/HF	0.02 (0.95)	0.05 (0.11)	0.044	0.619
Mean BMP(t/m)	-4.71 (5.82)	-0.44 (7.15)	0.790	0.244
SDNN	12.21 (32.29)	1.50 (10.78)	-0.444	0.421
RMSSD	4.35 (30.05)	2.80 (13.75)	-0.066	0.903
Other parameters				
PPT (KG)	-0.34 (0.46)	-0.28 (1.18)	0.067	0.891
VAS(CM)	0.85 (1.3)	0.28 (1.38)	-0.425	0.448
SAR (CM)	-0.15 (1.26)	-0.18 (1.82)	-0.019	0.973

Note: LF, sympathetic activity; HF, para-sympathetic activity; LF/HF, LF divide HF; Mean BMP, average pulse; SDDN, pulse standard deviation; RMSSD, root mean square standard deviation; PPT, pressure pain threshold; VAS, visual analog scale; SAR, sit-and-reach; post minus before, the value of post-protocol minus pre-protocol; ES, effect size.

Discussion

From this experiment, we could not find a significant difference after the protocol in the LFVT group or between the LFVT group and the control group. Considering the safety of the participant, the 8 HZ vibration instrument was used. However, we found in this study that the time duration of intervention and the frequency of vibration did affect the effect of LFVT.

Considering the LFVT, low frequency refers to 0-45 HZ[19]. One previous study showed that vibration therapy at 30 HZ could produce adverse effects on some physiologic systems; some parameters were 7 times higher than what was considered the safe threshold[20].

We used the 8 HZ vibration frequency in the current study because of some reasons. These include safety utilization; favorable experience for the participants when we try LFVT; and confirmation of a study that the low-frequency vibration (15 HZ or lower) after exercise could accelerate cardiovascular autonomic recovery after exercise[21]. In addition, during the study period, the vibration instrument which was lower than 15 HZ we could find in the market was 8 HZ.

Some studies[22-24] showed that LFVT could provide beneficial effects on recovery from fatigue in the longer term. One study found that 15-minute percussive massage therapy (vibration therapy) may improve tissue hardness, skin temperature, and pain intensity[25]. Another study also found that local vibration treatment was effective for male and female volunteers under a session of 15-min intervention[26]. For the longer time duration intervention there were also beneficial effects on the participants. One study

showed that 8-vibration sessions (15 minutes per session) decreased the state of tension anxiety, muscle fatigue, and the perception of pain[27].

There was no significant difference in this study may be because the time duration of intervention was too short to cause a substantial effect. Another possible reason may be because the 8-Hz lower frequency vibration itself provided too low and inadequate energy intervention. Future studies may explore the appropriate frequency for LFVT. For the frequency of vibration therapy, a frequency of 26 Hz vibration therapy precluded the muscle stiffness of the athletes after 10 bouts of 60 seconds of static half squats and it can be suggested to become the potential warm-up exercise and regimen to promote the subsequent performance. A 12 Hz frequency whole body vibration could provide a positive result on the parameter blood lactate[28]. About the whole body vibration therapy, vibration properties of 18 Hz led to significant trunk neuromuscular control improvements for the participants in the experimental group before and after a muscle fatigue protocol[29].

This study has some limitations including being a pilot study with a small sample size, a short period of exposure to the intervention, and no follow-up period. Further study should explore the effects of vibration therapy that apply over a longer period and more sessions. Moreover, a larger sample size with a randomized controlled trial should also be verified.

Conclusion

After the intervention, although there is no significant difference between the experimental group and the control group or in the experimental group, the PPT parameter had shown a positive result.

Take home messages

Four minutes of LFVT therapy did not show significant effects on lower back muscle recovery from fatigue in college football athletes based on sit-and-reach, pressure pain threshold, visual analog scales, or heart rate variability.

Conflicts of interest

The authors declare no conflict of interest.

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