

Plantar Flexor Muscles Asymmetry and Their Lower Strength Is Maybe Related to Development of Low Back Pain during Prolonged Standing

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Abstract

Introduction: Research has shown that there are some risk factors in creating and developing low back pain with prolonged standing. To have the predisposing factors in development of LBP during prolonged standing recognized, this study was conducted to investigate the maximal voluntary contraction (MVC) at selected groups of muscles and some of the psychological aspects in back-healthy subjects who developed LBP during prolonged standing. **Materials and Methods:** 25 back-healthy subjects and 14 chronic nonspecific LBP completed anxiety inventory (STAI), Tampa Scale for kinesiophobia (TSK) and pain catastrophizing scale (PCS) questionnaires. Dynamometer was used to assess MVC of the selected groups of muscles. Finally back-healthy subjects get tested for 2 h prolonged standing protocol and based on a visual analog scale (VAS) were categorized as pain developers (PD) or non-pain developers (NPD). **Results:** Ten subjects (% 40) with developing pain were categorized as PD. There were no significant difference at psychological aspects between three groups of PD, NPD and LBP. But analysis of MVC showed PD and LBP groups had less MVC at the left plantar flexors than left plantar flexors of the NPD group. Also PD and LBP groups had significantly more between two sides asymmetry at MVC at the plantar flexors compared to NPD group. **Discussion:** This preliminary data suggest less MVC and asymmetry of MVC at plantar flexor muscles maybe related to development of the LBP during prolonged standing in the back-healthy people. Further study is needed to investigate other functions of plantar flexors and their probable relations to development of LBP during prolonged standing.

Key words: prolonged standing, voluntary contraction, anxiety, psychological, low back pain

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Introduction

Low back pain (LBP) is a widespread health problem as above 80% of people experience at least one period of LBP during their life cycle (1). Yet, several risk factors have been identified for LBP one of which is prolonged standing named as PDs (pain developers) (2, 3). Recently it has been determined that 40% to 70% of back healthy people experience some degree of acute LBP during 2 h static standing (4). In previous studies related prolonged standing some differences of motor control strategies also some predisposing factors in development of LBP have been detected (4-9).

PDs do not have any history of LBP in their life so pathoanatomical defects could not be related to development of their LBP. Therefore, approach of kinesiopathological model (10) such as evaluation of function of muscles may be effective to explore causes of LBP development during prolonged standing. Marshall et al. found that side bridge endurance is less common in PDs (11). Assessment of muscle strength tests have become a popular form of testing muscle function in movement-related sciences because of their obvious validity for muscle-function assessment (12). Consequently, the primary purpose of this study was to investigate the relationship between muscle strength and LBP

during prolonged standing through the assessment of the maximal voluntary isometric contraction (MVC) of the selected groups of muscles include: dorsi and plantar flexors, abductors and adductors and extensors and flexors of the hip, flexors and abductors of the core, flexors and abductors and extensors of the shoulder between PDs and NPDs (non-pain developers).

Need to perform prolonged static standing can increase anxiety among many people that is implicated to state anxiety and individual differences in response to such situation is implicated to trait anxiety. Based on Attentional Control Theory (13), anxiety decreases attentional control and increases attention to threat-related stimuli. People in an anxious state frequently worry about the threat and try to develop effective strategies to decrease anxiety to achieve the goal (13). In addition, Bolmont *et al.* showed that anxiety can influence abilities to maintain balance control in healthy subjects (14). Another purpose of this study was to assess anxiety with the help of Persian version of Spielberger's state-trait anxiety inventory (STAI) with assessment of two other psychological aspects including; fear of movement through the Persian version of TSK and pain Catastrophizing with the Persian version of PCS questionnaires. STAI is commonly used to measure trait and state anxiety (15).

Nelson-Wong *et al.* in a longitudinal study determined PDs during 3 years follow up had higher rate of clinical LBP and concluded PDs may be considered as preclinical group who are at increased risk for future LBP (16). Also there are some evidence of similarities between PDs and nonspecific LBPs (17) so in this study a group of chronic nonspecific LBP considered for comparison with PD group.

Materials and Methods

Subjects

Twenty five back healthy people and fourteen people with LBP were selected to participate in this study from the university students at the age range of 22 to 28 years old and with BMI between 19 to 25. There was no significant difference between the demographic of 3 group of subjects (Table 1).

Inclusion criteria for back-healthy people were no lifetime history of LBP that last for more than 3 days or the one which required them to visit a medical professional. Also they were not engaged in activities or tasks that required prolonged static standing and did not take part in recreational sports up to three times a week during the past 12 months. Exclusion criteria on the other hand were, any significant structural disorder and any

report of LBP at the beginning of prolonged standing protocol.

Inclusion criteria for people with LBP included, having nonspecific LBP last for more than 3 months and exclusion criteria were disc protrusion that causes referred pain at the distal of gluteal fold, radicular pain, spondylolisthesis, any history of spine surgery and infection or fracture of the spine.

All subjects were asked to sign written informed consent approved by the ethics committee of Tarbiat Modares University before participating in the experimental procedure.

Experimental protocol

Participants filled out the questionnaires of demographic data and Persian version of STAI, TSK and PCS. The healthy subjects complete the psychological questionnaires in the day of prolonged standing protocol.

STAI has 20 items to assess trait anxiety and 20 to measure state anxiety. The TSK has 17 items that participants answered using the scale of agreement and disagreement. Higher score indicated the higher fear (18). PCS includes 13 items that indicate thoughts and emotions that people may experience during pain. Each item was scored based on never to ever scale (19).

Dynamometer (in kilogram) model of 01165, made in America was used for MVC testes. Participants were instructed to produce their maximal isometric effort.

The groups of the dorsi and plantar flexors, abductors and adductors and extensors and flexors of the hip, flexors and abductors of the core, flexors and abductors and extensors of the shoulder muscles were assessed. Position of the assessor and participants was defined based on grade 5 Daniels and Worthinghams Muscle Testing book except for dorsi and plantar flexors that were performed at spine position (20). Dynamometer were placed on distal end of limbs expect for flexion of the core that was placed on the manubrium body and trunk extensors placed on upper thoracic. Tests were performed on the same position for all participants and performed in the midrange. Each test was repeated two times then mean of the data was used for analyses.

For prolonged standing protocol, in the other day within same week, just back healthy peoples recruited, on the other hand LBP subjects just were evaluated for the questionnaires and MVC testes. This examination was not performed on the same day for healthy subjects because it might have diminished effects of the fatigue of MVC assessments. All subjects were asked to wear their own athletic shoes. This protocol was designed based on Gregory and Callaghan definition (4). Participants stood in front of a work desk adjusted to a height of 5 cm below elbow height for each participant and in confined space of 0.50 m × 0.46 m for 2 h while perform 3 light task (Figure 1). Tasks included designing with cubes of wood, sorting the kinds of chocolates and waiting without performing

Table 1. Participant characteristics

	PD (n=10)	NPD (n=15)	LBP (n=14)	P value
Age (year)	25.1 ± 1.8	24.8 ± 2.4	25.6 ± 3.5	0.71
Male (%)	7 (70%)	6 (40%)	4 (28.5%)	-
Weight (kg)	69.1 ± 6.4	67.7 ± 8.1	63.2 ± 9.7	0.30
Height (m)	1.7 ± 0.03	1.7 ± 0.10	1.6 ± 0.09	0.19
BMI	23.2 ± 1.2	22.9 ± 2.3	23.3 ± 3.4	0.92

Table 2. Participant questionnaires and MVC results:

	PD (n=10)	NPD (n=15)	LBP (n=14)	P value
TSK	29.7 ± 10.8	34.4 ± 10.6	32.6 ± 5.7	0.44
PCA	14.1 ± 3.6	12.0 ± 3.1	15.0 ± 3.2	0.05
STAI (state)	34.1 ± 6.6	35.6 ± 4.2	32.6 ± 5.7	0.33
STAI (trait)	38.9 ± 8.2	40.0 ± 5.1	39.0 ± 4.9	0.87
RPF MCV	0.76 ± 0.18	0.87 ± 0.18	0.85 ± 0.28	0.46
LPF MCV	0.59 ± 0.15	0.80 ± 0.17	0.67 ± 0.20	0.02
PF MCV asy	27.5 ± 10.4	15.8 ± 9.6	25.5 ± 14.2	0.03

TSK=Tampa Scale for kinesiophobia, PCA=pain Catastrophizing scale, STAI=state-trait anxiety inventory, MVC=maximal voluntary contraction, RPF=right plantar flexors, LPF=left plantar flexors, asy=asymmetry

task. Each task lasted for 40 minutes and was randomly selected. The participants were not allowed to lean about the task with their upper extremities.

Every 15 minutes, the level of perception of pain at low back was recorded with a 10 mm VAS score. If during standing they reported VAS ≥ 1, one was categorized as PD subjects. The VAS < 1 was considered as the minimal clinical importance, and VAS < 1 was considered as the minimal clinical importance (21).

It should be noted that, only healthy back subjects did the prolonged standing task.

3. Analysis of data

Data of MVC for every subject was normalized to the body size using the following allometric formula:

$$S_n = \frac{S}{M^b}$$

where S is muscle force (recorded by a dynamometer), m is body weight and b is the allometric parameter and constant value=0.067 (12).

After data analysis of plantar flexors muscles MCV, percentage of sides asymmetry were also calculated using the following formula:

$$\frac{\text{higher MCV} - \text{lower MCV}}{\text{lower MCV}} \times 100$$

SPSS version 24 was used for all statistical analyses.

ANOVA tests were run on the participant questionnaires, MCV and between sides asymmetry MCV results to compare three groups: PD, NPD and LBP.

When Post hoc multiple-range tests were required, Pairwise comparison with LSD were used. The alpha level was set less than 0.05 as significant for all tests.

Results

After prolonged standing protocol for 25 back-healthy subjects, 10 subjects (40%) were categorized in PD group and 15 subject (60%) in NPD group.

There were not statistically significant differences between questionnaires of STAI, TSK and PCS among 3 groups (Table 2).

Analysis of the MVC showed PD group had less MVC at the left plantar flexors than NPD group (Figure 2). Moreover, PD group had significantly more asymmetry at the MVC of the plantar flexors between sides than NPD. Between PD and LBP groups there were no significant differences at MCV and MCV asymmetry (Figure 3).

Discussion

The primary purpose of this study was to investigate probable differences regarding MVC and their asymmetry between back-healthy subjects who develop LBP and non-pain developers during 2 hours standing, also the similarity between these PD subjects to



Figure 1. Prolonged standing protocol

chronic LBP subjects from the MVC of the dorsi and plantar flexors, abductors and adductors and extensors and flexors of the hip, flexors and abductors of the core, flexors and abductors and extensors of the shoulder muscles and psychological aspects with the questionnaires of STAI, TSK and PCS.

Healthy subjects after prolonged standing based on their VAS reports were divided into PD or NPD groups. On existence pain in subjects, ten subjects were categorized in PD and fifteen subjects in NPD group.

Participant characteristics and questionnaires included state-trait STAI, TSK and PCA results did not show significant differences between PD, NPD and LBP groups. Therefore, there were no psychological differences at this individual factors. In previous studies, Sorensen with questionnaires showed the psychological factors of fear of pain and pain Catastrophizing could be related to the intensity of pain in PDs, but similar to this study, these factors did not have any differences between PDs and NPDs (22).

Analysis of MVC data demonstrated that the only significant difference was in the left plantar flexors strength so that PD groups had less MVC in this muscles than NPD group, while PD and LBP groups did not have significant differences. Also comparison of percent of two sides asymmetry of plantar flexors determined PD and LBP had more significant asymmetry than NPD group.

The plantar flexors are one of the most important muscles in postural control at quiet standing. In the optimal erect posture, the line of gravity passes anterior to the ankle joint axis (23). This creates a dorsiflexion moment that must be opposed by a fairly continuous activity of soleus and gastrocnemius to forward motion of the tibia (24). Mochizuki et al. determined a common function of the soleus muscle by acting to control anteroposterior sway between the legs (25).

Slight deviations from the optimal posture are to be expected in a healthy peoples because of the many individual variations found in body structure (26). Also faulty postures can cause structural adaptations such as ligamentous and muscle shortening or lengthening will occur (26). Furthermore, the kinematics of the lower limb alters pelvis and lumbar spine posture (27). Therefore, lower and asymmetry of plantar flexors could be related on LBP development during prolonged standing for some reasons that need to be investigated in future researches. Also similarity between PDs compared to LBP at this variables maybe demonstrate that this parameters are predisposing factors instead of adaptive in non-specific LBP.

Lower extremity fatigue, pain, swelling and discomfort due to prolonged standing have been reported in numerous studies (28-31). Additionally, in this study, feeling leg discomfort and pain was a main complain among many subjects either PDs or NPDs.

Further studies are needed to examine other functions of plantar flexors and their probable relations with development of LBP during prolonged standing.

Marshall et al. found side bridge endurance was less in PDs although there were no differences at strength of the hip abduction between two groups (11). In another study, Sorensen found the lumbopelvic region in PDs moved earlier in left hip abduction than right hip abduction and concluded this asymmetry at the lumbopelvic movement patterns may be a risk factor in LBP development during prolonged standing (9). Similarly, the results of this study compatible with previous studies showed it could be a risk factor in LBP development during prolonged standing.

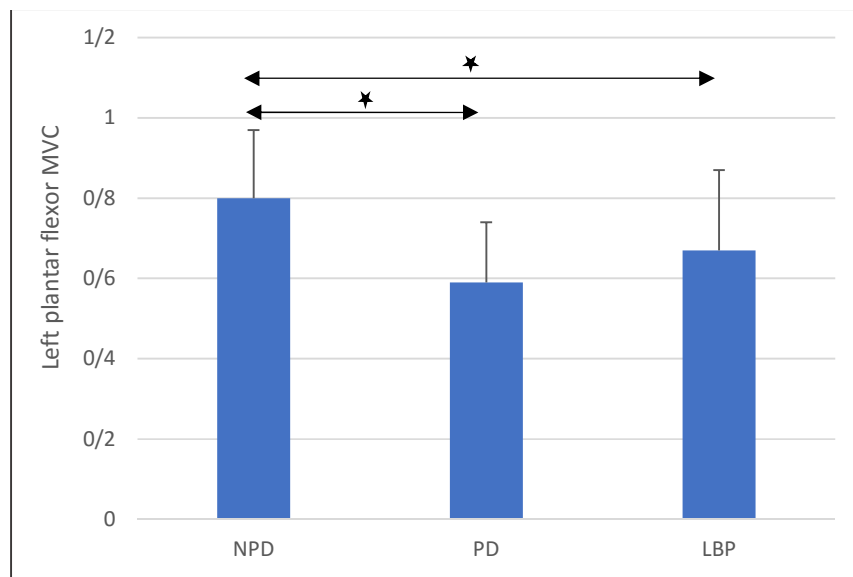


Figure 2. Mean and standard error bars of left plantar flexors MVC; * indicated significant difference ($P < 0.05$)

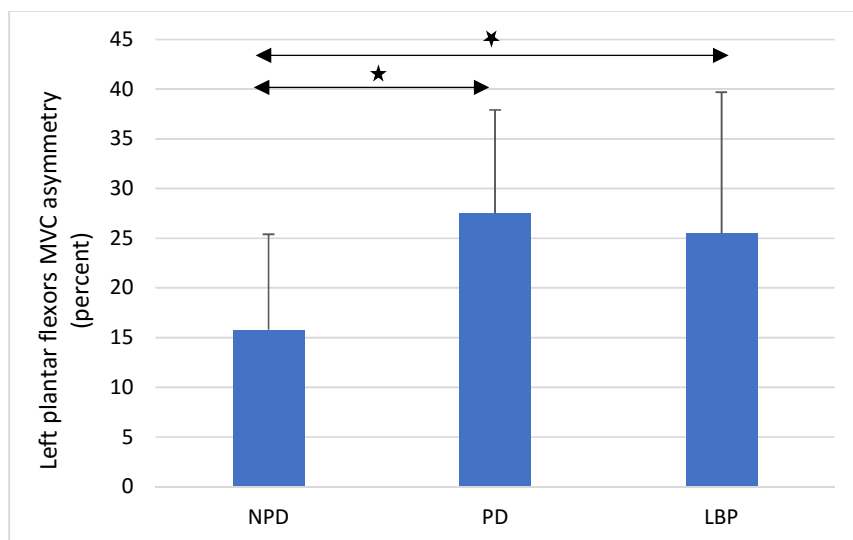


Figure 3. Mean and standard error bars of plantar flexors MVC asymmetry; * indicated significant difference ($P < 0.05$)

Conclusion

The purpose of this study was to assess MVC of some groups of muscles and psychological aspects among 3 groups of PD, NPD and LBP. The results showed the only difference was at plantar flexor muscles MVC. PD and LBP had significantly lower MVC in left plantar flexors also larger between sides asymmetry at this muscles compared to NPD group. Further studies are needed to investigate other functions of plantar

flexors and their probable relations with development of LBP during prolonged standing.

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Conflict of interest:

None

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Authors' contributions:

All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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