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Assessment of Vertical Ground Reaction Force at Propulsion Phase of Gait in Chronic Non-Specific Low Back Pain

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Abstract:
Purpose: To examine the difference in the vertical ground reaction force (GRF) value at the propulsion phase of gait in patients with CNSLBP and healthy subjects.
Methods: Nineteen patients complaining of CNSLBP and nineteen matched healthy volunteers with age (20.5 ± 2.12 y) were included in this study. The vertical GRF was assessed by the Tekscan pressure walkway system with a pressure mat to detect the vertical component of the ground reaction force at the pre-swing phase of gait.
Results: no statistically significant differences were found in vertical GRF between normal and CNLBP patients' groups (p = 0.598).
Conclusion: The CNLBP patients did not have any apparent kinetic changes expressed by Vertical GRF which indicated alternative substitutions that may affect gait kinematics which need further studies to confirm.
Keywords: Chronic low back pain, vertical ground reaction force, Tekscan, walkway; propulsion phase.

1. Introduction:

Chronic low back pain (CLBP) represents the top recurrent orthopaedic disorder leading to significant dysfunction and job avoidance (1,2). CLBP can be presented at any age and put a major burden on the health care system. More than 80% of people may have some sort of LBP at least once in their life (3,4).

Nonspecific low back pain (NSLBP) is considered when unknown pathological and anatomical causes are confirmed. The common terminology used to express a patient's symptoms is nonspecific low back pain (NSLBP) which accounts for 85 to 90% of all forms of low back pain (5). Nonspecific low back pain is usually reported as pain at the sacral and lumber regions that may be associated with pain referred to one or both thighs. Its Chronicity can be recognized when the duration of pain is lasting more than 12 weeks (5,6).

Walking is a basic human activity that is associated with a variety of forces and moments across each joint secondary to their interaction with the ground which was known as GRF (7). Walking is an activity that has multiple benefits to human health as it aids in the reduction of the risk of obesity, improves aerobic capacity and improves general health. Therefore, walking as an exercise is recommended as a solution to many health problems and it is generally recommended as it improves the overall body fitness (8).

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Evidence supported that remaining active is very important in low back pain management. Therefore, many programs were designed to reeducate patients with low back pain about the normal walking pattern (7). Hendrick and his colleagues (2011) reported that patients with chronic low back pain have significant movement pattern changes which limit their walking capacity (9). Al-Obaidi and his colleagues (2003) suggested that walking velocity is the most affected kinematic parameter in low back patients (10) while Bertrand-Charette and his colleagues (2021) documented that the main controller of walking velocity is the propulsion force at the stance phase of walking (11).

There was a strong direct relationship between low back pain (LBP) and walking velocity, Therefore when walking velocity as a kinematic parameter is mentioned The kinetics assessment may explain the variability in walking speed. Zahraee and her colleagues (2014) reported that CNSLBP patients decrease their vertical GRF at the propulsion phase of walking to modulate paraspinal muscle overactivity and then decrease back pain (12). Although Zahraee and her colleagues (2014) suggested that this difference between healthy subjects and patients with CNLBP in their GRF value at the propulsion phase of walking was not statistically significant (12) and this result contradicts a previous study that found a significant difference in gait analysis (13). Therefore, our study was conducted to try to solve this debate by examining the vertical GRF at the propulsion phase of walking in CNSLBP and healthy volunteers to understand the possible kinetics changes that may be associated with pain.

2. Materials and Methods:

This cross-sectional study was performed at the faculty of modern technology and Information from December 2022 to April 2023 with the ethical number NO: P.T.REC/012/004109. Nineteen patients complaining of CNSLBP, and nineteen matched healthy volunteers were included in this study. The vertical GRF were assessed by the Tekscan pressure walkway system Inclusion Criteria: for Patients with CNSLBP: Aged between (18-40), Low back pain that was persistent for more than 3 months (6). Both gender (male and female) and BMI 18-25 kg/cm2 (14). Healthy subject: Matched participants for age, BMI and free from any musculoskeletal pain. Exclusion Criteria: Low back pain due to other causes rather than mechanical type such as anatomical or pathological condition (disc prolapse, stenosis and spondylolisthesis) (15). Previous lumber surgery, Recent Lower limb injuries and Radiculer pain in the lower limb.

Vertical GRF assessment:

Tekscan walkway system was used for vertical GRF measurements under forefoot at the propulsion phase of gait, The Tekscan system (matscan® system (Boston, MA, USA)). The system consists of a 5 mm thick platform (432 × 368 mm), comprising 2288 resistive sensors (1.4 sensors/cm2) which sample data at a frequency of 40 Hz. The pressure mat assessed the pressure at the plantar surface of the foot (16). Before data collection, age, height, weight and leg length symmetry was recorded. Data of GRF was collected by the two-step gait initiation method in which the participant was asked to step on the platform several steps barefoot (17). Three trials were recorded for each foot over the pressure mat (16). Data was collected from pressure under the forefoot at the terminal stance phase of the back foot during the gait cycle which represents the terminal stance phase of the back foot and initial contact of the front foot and taking the value of the peak vertical GRF under the forefoot at this time (18)(19).

3. Results:

The sample of the current research was 38 participants with 19 healthy subjects in group A (normal) and 19 patients with chronic nonspecific low back pain in group B (Low Back Pain). The distribution of males and females in the normal group was 63.2 % (12) and 36.8 % (7) respectively, while in the low back pain group, it was 36.3 % (5) and 73.7 % (14) respectively. Comparing the sex distribution for all patients in the control and treatment groups using the Chi-square test revealed that there was significant difference between groups (p = 0.02). Comparing the mean values of demographic data for all subjects in the normal and low back pain groups using the independent sample t-test revealed that there were no significant differences between them in age and weight. On the other hand, there was a significant difference in participant's height between normal and low back pain groups (p = 0.033), **Table 1.**

Between group comparisons:

Independent sample *t*-test between groups was conducted to investigate the difference in the vertical GRF between groups; Group A (Normal) and Group B (CNSLBP). There was no significant difference in the Vertical GRF/weight between groups as adjusted P-value after considering height and sex as covariates in VGRF calculation was (.552), **Table 2.**

Table 1: Descriptive statistics for the mean values of demographic data of all subjects (normal and low back pain groups)

Variable		Mean ± SD		t-value	*P*-value	Sig.
		Group A (Normal) N = 19	Group B (Low back pain) N = 19			
Age (years)		20.58 ± 1.465	20.21 ± 2.123	0.623	0.538	NS
Weight (kg)		66.11 ± 9.944	61.84 ± 6.866	4.263	0.133	NS
Height (cm)		173.79 ± 10.748	166.79 ± 8.593	2.217	0.033	Sig
BMI (kg/m^2)		21.784 ± 1.547	22. 268 ± 2.221	-0.778	0.442	NS
Sex	**Female**	7 (36.8%)	14 (73.7%)	-2.39	0.02	Sig
	Male	12 (63.2%)	5 (36.3%)			

***SD= Standard deviation, *t-value=t-statistic, *P-value=probability, *Sig. =Significance, *NS=non-significant.**

Table 2. Mean values and significant difference between Normal and Low Back Pain subjects.

Variables	Group A (Normal) N = 19	Group B (Low Back Pain) N = 19	MD	F*	P value*	Sig
	$\overline{X}$ ± SD	$\overline{X}$ ± SD				
Vertical ground reaction (force/weight)	135.24 ± 11.42	137.13 ± 10.46	-1.89	.360	.552	NS

*** Corrected p-value for height (0.740) and sex (0.597) after considering Them as covariates in VGRF calculation.**
*** Adjusted F and P-value after considering height and sex as covariates in VGRF calculation.**

4. Discussion:

The current study was conducted to understand the possible relationship between CNSLBP and change in kinetic gait parameters specifically vertical GRF at the propulsion phase of gait. Patients with CNSLBP walk at a slower speed compared to normal subjects (10) and the main controller of the walking speed is Vertical GRF (11). Therefore, the assessment of Vertical GRF gives us insight into the possible kinetics change in the walking patterns of CNLBP patients.

The current study found no statistically significant differences in vertical GRF between the two groups. The finding of our study regarding the vertical GRF agreed with the results of Zahraee and her colleagues (2014) who observed that CNSLBP patient's VGRF didn't significantly differ from healthy subjects (12) while contradicting the result of Da Fonseca et al (2009) who observed that there is a significant difference in Vertical GRF between the two groups (13), The possible rational under this contradiction is that patients in that study were complaining from low back pain with referred leg pain for at least 6 months.

This leg pain may contribute to the reduction of the forces exerted by this leg on the ground which helps to reduce their complaints.

The results of Simmonds., et al (2007) solved the contradiction between the current study and Da Fonseca et al (2009) study as agreed with the current study as they assessed VGRF in the CNSLBP group without referred leg pain and normal subjects and found that there was no significant difference between the two groups. However, they walk at a slower speed compared to the normal group, while at the same time assessing the same variable between CNSLBP with referred leg pain which had a significant difference in VGRF (20).

Finally, while there was a significant difference in subject height as a result of difference in sex distribution between groups, this difference does not affect the result of the ground reaction force value as this variable taken as covariate in the statistical procedure and the resultant Corrected p-value for VGRF was (0.552). This result agreed with Jansen and his colleagues (1982) who documented that height and sex difference does not affect vertical GRF value (21).

5. Limitations:

The current work took a step toward understanding the walking kinetics of low back pain patients but it had some limitations that include:

1) Absence of kinematic assessment of the phases of gait for the study population.
2) The sample involve only one category of low back pain subjects (chronic non-specific low back pain) so that the possible relationship between the LBP and changes in walking kinetics not appeared.
3) In data collection there was a significant difference in height that may be as result of unequal sex distribution in both groups so more statistical calculation done considering height and sex as covariates in VGRF calculation.

6. Conclusion:

The CNLBP patients have no apparent kinetic changes expressed by Vertical GRF secondary to their complaints and compared to healthy subjects. This may indicate alternative substitution that may affect gait kinematics which needs further studies to confirm.

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