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The Comparison Between Before and After Cross Bag Walking Intervention on Gait Parameter and Center of Pressure

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Abstract

Background/Objectives: Purpose of this study is to analyze quantitatively the morphological gait parameters and displacement of the center of pressure(COP) of the human body during walking before and after carrying the cross bag and utilize it for treatment.

Methods: The subjects of this study were 29 healthy adult males in S University. This study used 3D motion analyzer and ground reaction force plate. This study was conducted as a single group without a control group and compared the gait parameters and center of pressure displacement when before and after wearing the cross bag.

Findings: The mean walking speed decreased slightly (m/s) before and after wearing cross-bag, but there was no statistically significant difference($p>.05$). However, when walking after wearing the cross-bag, the stride length (cm) of the left foot decreased, so there was a significant difference($p<.05$) but the stride length (cm) of the right foot decreased but there was no significant difference($p>.05$). The center of pressure displacement was significantly different between the left, right and left and right foot before and after($p<.05$), but there was no significant difference in the center of pressure displacement between the left and right foot. The left foot was not significantly different($p>.05$), but the right foot was significant ($p<.05$).

Improvements: It is believed that pain and other symptoms will be improved by providing the dynamic muscular strength increase with a significant recovery from the functional state of the patient by making patients with mild lesions such as mild knee arthritis or anterior cruciate ligament do cross-bag gait training.

Keyword : Cross bag, Asymmetric load, 3D motion analysis, Force plate, Gait parameter, Center of pressure, Osteoarthritis, Anterior cruciate ligament

1. Introduction

People use different kinds of bags in their daily lives. Bag preferences vary with age and backpacks are used primarily by children, while cross-bags and handbags are mostly used by adults[1]. The weight and the wear method of the bag are one of the factors that affect our body and the weight added to the bag acts as an external load, affecting many features of the body[2,3] and the weight of these bags and the walking are closely related.

Gait is the most basic way and the most common form to move the human body and normal walking is characterized by symmetrical movement around both limbs and L5 / S1 joints, the process using musculoskeletal and nervous systems collectively, repetitive and continuous movement that requires balance and high coordination of the body and depicts walking actually[4,5]. In addition, gait may cause the body to deform asymmetrically depending on the type of bag or how to carry. In general, as we go to school, grow and enter society, we carry various kinds of bags, unlike when we were young. One example is a cross-bag.

Cross-bags are carried by over 90% of students. About 55% of students carry cross-bags and most students carry a bag heavier than the recommended weight[6]. When people carry cross-bags, they maintain balance by unconsciously changing the alignment of the shoulders and spine[1]. In addition, the left and right asymmetry of the trapezius muscle was clearly observed while carrying cross-bags on the right side of the body, similarly, the asymmetry of abdominal muscle was actively observed[7]. In general, when walking while carrying a bag, physical stress is applied to the human body due to the weight of the bag and physiologically or mechanically affected, resulting in changes in dynamic balance and posture[4]. This may cause the change of COP put on the ground.

The COP changes the position of the pressure center line and the human body brings the pressure center line to the base center to maintain equilibrium. In addition, the adaptation mechanism of the human body appears to maintain balance and reduce walking energy consumption, such as rearranging the human body segment in an abnormal posture to bring the centerline forward and further forward. Ground reaction force plate is used to measure the COP and postural movement. In addition to measuring the standing still or walking of a person, it can also confirm the COP displacement caused by the body.

The gait parameter system plays a very important role in health and sports. For example, gait parameter can help manage early diagnosis of neurodegenerative diseases and the movement symptoms that occur from them[8]. Walking parameters, however, are widely used and accurate systems but are expensive and cannot be used in many clinical environments[9]. Low-cost gait parameter systems have emerged, but there was no information on the accuracy of these systems compared with more established systems[10]. According to Lee, the type and weight of the bag can be negatively affected by the body, resulting in asymmetrical loads, but using cross-body carrying change reduces asymmetry and negative effects[1] and according to Qureshi and Shamus. people carrying cross-bags showed evenly distributed weights through the lower thighs, although they initially gained weight. The sagittal view also revealed more physical stress in the backpack than in the cross-bag[11].

In addition, Abutaleb studied reported, carrying the cross-bag for a long time can lead to musculoskeletal imbalance and postural asymmetry[6]. Repeated postural asymmetry can lead to shoulder, neck and back pain as asymmetric muscle activity occurs. Also, carrying a bag that weighs more than 15% of weight can increase back pain and affect posture and gait[11]. Particularly cross-bag of many bags increase back pain due to back asymmetry. Also, according to Pascoe et al., as the weight of the bag increases and the load is asymmetry, the stride length becomes shorter and the foot contact time increases[17].

In many studies, there have been many negative views that cross-bags cause asymmetry in body alignment by placing asymmetrical loads. Therefore, the purpose of this study is to analyze quantitatively the morphological gait parameters and displacement of the COP of the human body during walking through the analysis of walking before and after carrying the cross-bag and displacement analysis of COP and to present the biomechanical basic data for correct walking and to use them for treatment.

2. Materials and Methods

2.1. *Participants*

The subjects of this study were 29 healthy adult males at S University, located in A city, Chungcheongnam-do, who had no history of ankle, shoulder, knee injury or surgery within the past 6 months. The subjects were fully informed of the content and purpose of this study before participating in this study, which was done after receiving consent to participate in the experiment. The characteristics of the subjects are as follows[Table 1]. This study was conducted with the approval of the Institutional Bioethics Committee of Sunmoon University(SM-201904-035-1). Participants were acquainted with the experiment method in advance through preliminary exercises and exclusion criteria are as follows.

(1) Those who have no musculoskeletal disorders such as orthopedic or neurosurgical injuries that affect walking in the upper and lower limbs

(2) Those who have no lesion or surgical history on the spine

(3) Those who have no external walking abnormality such as lame walking

(4) Those who have no structural abnormality of leg or foot

(5) Those who have no corn or callus

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Table 1. Subjective characteristics(n=29)

Variable	Mean±SD
Age	24.76±9.21
Height(cm)	176.24±5.3
Weight(kg)	73.55±9.21

***mean ± standard deviation**

2.2. *Experimental procedures*

This study was conducted in experimental group only without control group as single group. Before entering the experiment, the subjects were fully informed about the research procedure and stability and then measured. To gait analysis and to see the COP displacement as experiment group when carrying a bag of the condition of not carrying a bag and condition of carrying a bag across one side, this study experimented 29 healthy male students to verify the effects of coplanar and cross body carrying.

In the condition of not carrying a bag, we made the marker of the motion analyzer attached and made them walk the 6m straight walk-way installed the ground reaction force plate at the same speed as usual on barefoot and their eyes look forward. After the measurement in the condition of not carrying a bag, we made them carry a bag across one side and walk on a straight way without curve for 40 minutes. For the load of the bag, we placed dumbbells in the bag to generate a load of 10% of the subject's weight and the length of the bag strap was such that the edge and the part of the bag reached the height of the iliac crest of the subject's waist. In the condition of not carrying a bag after walking for 40 minutes, we made the marker of the motion analyzer attached and made them walk the 6m straight walk-way installed the ground reaction force plate at the same speed as usual and their eyes look forward.

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This study measured twice before and after carrying a bag and when walking, if an abnormality of body occurred or the subject complained of difficulty, the experiment was discontinued immediately[Figure 1]. Schematic of the above research process is as follows[Figure 2].

Figure 1. An Experimental photography

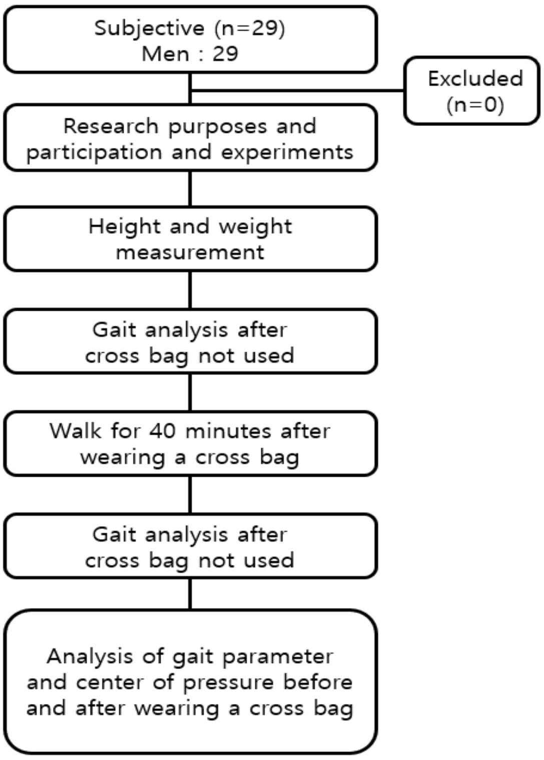

Figure 2. Experiment protocol flow chart

2.3. *Equipment*

This study identified the gait parameters and the COP displacement during walking as a single group. Prior to this study experiment, the experimenter measured height and weight using an automatic height scale(automatic BMI measuring stadiometer, BSM 370, Korea, 2011) to model the subjects using the Visual 3D program. In this study, 3D motion analyzer(Qualisys system-Qualisys Medical AB 41113, Gothenburg, Sweden), 6m walk-way and ground reaction plate were used and marker motion was tracked with 6 motion capture cameras(Qualisys Oqus 300)[Figure 3]. The experimenter wore both sleeveless and shorts to accurately recognize the markers. Marker attachment points were attached to both Anterior Superior Iliac Spine, Posterior Superior Iliac Spine, 3 Femur Shafts, 3 Tibia Shafts, Knee Medial / Lateral epicondyle, Ankle Medial / Lateral malleolus, Calcaneus and Foot 1st / 5th phalanges. A total of 29 markers were attached[Figure 4].

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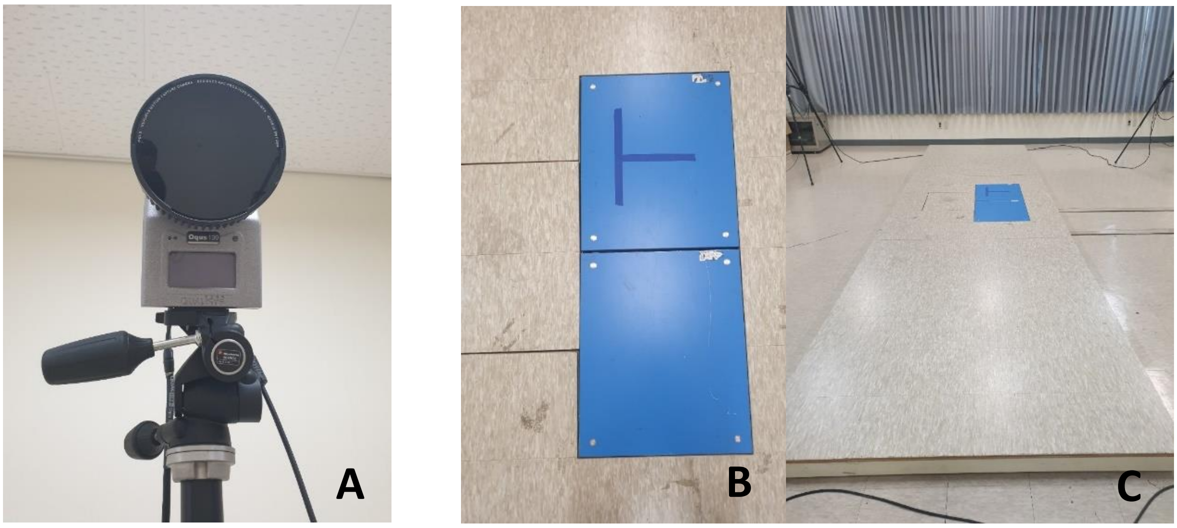

Figure 3. A:Qualisys system-Qualisys Medical AB4113, Gothenburg, Sweden, B:Force plate, C: 6m walk way

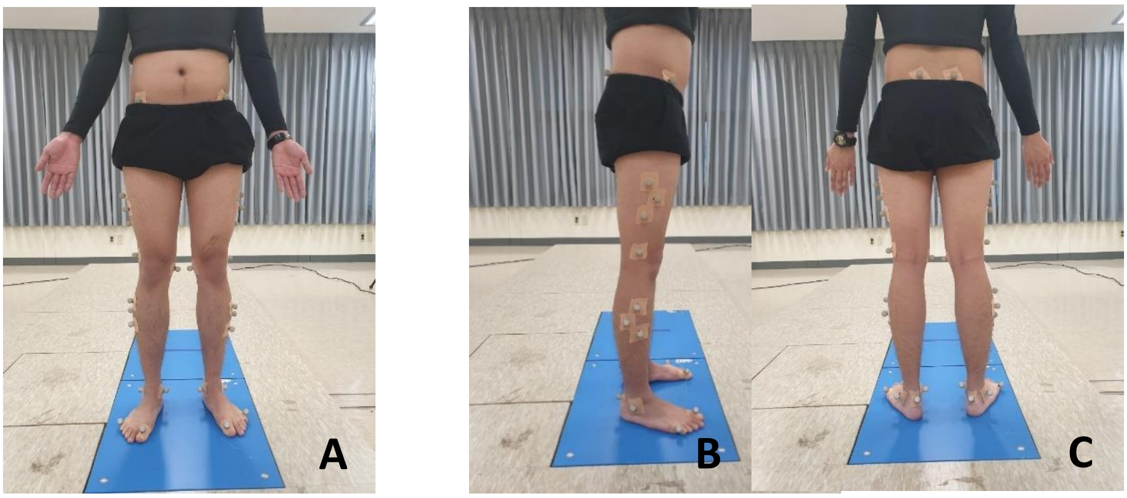

Figure 4. Marker attachment point A:Anterior, B:Side line, C:Posterior

2.4. *Statistical analysis*

SPSS version 17.0 for window was used for research data analysis. Also all statistical significance levels were set at $p<0.05$. Calculate the physical characteristics of the subjects of mean and standard deviation of all variables, the descriptive statistic was used. Also to compare before and after intervention was used to paired T-test.

3. Result

We measured the walking speed and parameters on walking before and after wearing the cross-bag. The average walking speed decreased slightly (m/s) from 1.20±0.49 to 1.19±0.38 before and after wearing cross-bag, but there was no statistically significant difference(p>.05). However, when walking after wearing the cross-bag, the stride length (cm) of the left foot decreased from 126.97±5.7 to 125.14±4.71, so there was a significant difference(p<.05) but the stride length (cm) of the right foot decreased from 124.97±5.53 to 124.38±5.48 but there was no significant difference(p>.05)[Table 2]. The stride length of the right and left foot was reduced compared with walking without a bag. When walking the cross-bag before and after wearing the cross-bag, as a result of the difference in displacement (cm) between left-right, front-back and top-bottom of the COP with the corresponding paired t-test, the left-right of the left foot showed significant difference(p<.05) from 36.37±19.03 to 55.29±22.47 and front-back from 132.08±32.94 to 154.89±51.98, but the top-bottom displacement of the left foot showed no significant difference from 833.93±114.3 to 872.73±124.56(p>.05). The left-right displacement of the right foot showed significant difference from 50.71±14 to 65.9±13.73 and front-back displacement from 136.18±32.55 to 152.55±32.44(p<.05), while the top-bottom displacement of the right foot showed no significant difference from 853.33±127.22 to 857.98±170.88(p>.05). The comparison in the COP displacement of the left foot before and after wearing the cross-bag showed no significant difference from 1002.38±149.82 to 1068.17±211.63(p>.05), while the comparison in the COP displacement of the right foot showed a significant difference from 1040.23±152.66 to 1091.18± 147.21(p<.05)[Table 3].

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Table 2. Analysis of gait parameters before and after cross bag

	No cross bag	Cross bag	t	P
Velocity(m/s)	1.20±0.49	1.19±0.38	-1.367	.18
Left stride length(cm)	126.97±5.70	125.14±4.71	-3.448	.00
Right Stride length(cm)	124.97±5.53	124.38±5.48	-1.897	.07

Table 3. Analysis center of pressure displacement before and after wearing cross bag

		Before	After	t	p
Left foot center of pressure displacement(cm)	**x**	36.73±19.03	55.29±22.47	6.387	.00
	y	132.08±32.94	154.89±51.98	2.675	.01
	z	833.93±114.30	872.73±124.56	0.907	.06
	Total	1002.38±149.82	1068.17±211.63	2.004	.05
Right foot center of pressure displacement(cm)	**x**	50.71±14.00	65.90±13.73	5.145	.00
	y	136.18±32.55	152.55±32.44	2.966	.00
	z	853.33±127.22	857.98±170.88	1.966	.08
	Total	1040.23±152.66	1091.18±147.21	3.942	.00

***x axis=Lateral-Medial, y axis=Anterior-Posterior, z axis=Superior-Inferior**

4. Discussion

In our daily lives, we must carry the necessary things with us and bags are important tools we use every day[23-25]. However, if you carry a heavy bag to one side for a long time or habitually, or the weight, shape, carrying style and location of the bag are incorrect, abnormal stress on the body can lead to musculoskeletal problems, such as scoliosis and muscle pain[14,22] and physiological influences can cause negative changes in dynamic balance and postural alignment[14-16,23], leading to the choice of an inefficient strategy for walking that required high coordination, which was a traditional theory. However, in order to correct the misalignment of the human body, sometimes asymmetric loads need to be used at the treatment site and we wanted to see the negatively reported asymmetric loads as therapeutic advantage. Therefore, in this study, we measured the difference between the gait parameters and the COP displacement of the human body during walking before and after wearing the bag, bio-mechanically examined what is the effect of cross-bags on the body and intended to use it for treatment.

As a result of study, there was difference in left-right and front-back of the COP displacement applied on the ground were different but there was no difference in the COP displacement applied vertically. The stride length for walking was different for the left foot, but not for the right foot. Previous studies have shown that carrying a bag while walking reduces stride length, gait speed as well as pelvic rotation[17,18,22, 32, 33]. Also, the amplitude of the unrestricted arm movements was greater to maintain coordination between the arm and leg movements. According to Kessel, the pelvis tilts forward, backwards, leftwards and rightwards and can rotate and play a role in supporting weight[19]. Previous studies have shown that stride length decreases due to reduced arm swing and trunk rotation. The rhythmic swing of the arm while the person is walking is an essential part of the complex movements of the head, upper limbs and lower limbs, the spine and the pelvis and plays an important balance in the movement of the transverse legs and pelvis. Knapik et al. reported that gait disorder may occur when walking with wearing a cross-bag and a bag placed to the right at the bottom can restrain body movements while walking, such as the toes on the same side out to gain body stability and compensate for the base of support[26]. He also reported that in the case of cross-bag, there is no difference in lateral pelvic inclination because it is loaded on one shoulder, but the change of front-back pelvic rotation decreases gradually as the weight of the bag increases[20]. Accordingly, as shown in the previous study, the results of this study showed that the stride length decreased when carrying by cross-bag and it was judged that there was no significant difference in the effect of the load on the walking speed compared with the load effect on the gait parameter.

While carrying things, if the load is too heavy or the wrong way to carry and walk, the change in walking pattern is affected by the movement of the human center and while normal walking, the center of the human body progresses smooth regularly and symmetrically along up-down, left-right directions and the limbs move in harmony, while when walking wearing or carrying a load like a bag, irregular movement of the center of the body appears[15,21]. The point of action of the horizontal plane at the COP is a point on the pressure distribution plate where the force vector of vertical force begins. However, because the force acts on the entire sole of the foot when the sole is in contact with the ground, it is not called one point, so it is called the pressure center[4]. According to previous studies, it was assumed that the smaller the balance change, the faster the walking speed. Also, the gait speed before wearing the cross-bag is faster than after wearing cross-bag, which means that the body balance is better than walking wearing the cross-bag. The essential factor that plays the maximum role in the gait system is called balance control, and in order to achieve the best gait strategy, efficient balance pattern and posture control are needed[27,28]. The results of this experiment showed a significant difference in the balance between left -right and front-back, which has a significant effect on the balance. Also, we found that the COP for the vertical occurs a passive center of gravity shift on the opposite side to compensate for the tilt of the center of gravity, so that the COP on the left is higher than the COP on the right and to balance the body through high braking force and to ensure stability during the standing period[29]. In recent years, lesions with load such as mild knee arthritis or anterior cruciate ligament have been increased and currently exercises used for rehabilitation in arthritis patients generally focus on muscular strength, endurance and joint flexibility. However, we believe that this type of classical exercise program cannot produce optimal functional dose levels. Exercise should also satisfy daily activities and increase neuromuscular control. Diracoglu et al. reported that adding exercise nerve and balance exercises to help restore nerve muscle to basic strengthening exercises provides dynamic strength increase with significant recovery from the patient's functional status[30]. Mcquade and Oliveira also reported that the symptoms did not worsen when given a gradual resistance, such as wearing a cross-bag, gained considerable strength and improved pain and other symptoms[31].

This study is expected to provide meaningful information to gait-related researchers and ordinary people using bags. Nevertheless, this study has limitations. It did not consider the carrying method of the bag during the normal use of the subject and could not control the physical change caused by the carrying method of the bag, because it randomly extracted the subjects, Therefore, it is difficult to standardize the gait characteristics because only a short-term response was recorded by carrying the bag across from the left shoulder to the right. The future study is needed to supplement the above-mentioned limitations and further study is needed to secure scientific evidence data such as foot pressure studies through walking in various environments and study of lower limbs joint moment for gait characteristics and the methods to treat and prevent various musculoskeletal diseases should be studied later.

4. Conclusion

This study measured quantitative COP variation and calculated kinematic gait parameters using a 3D motion analyzer and ground reaction force plate to quantitatively analyze the movement morphological walking parameters and the displacement of the COP in the human body when walking and to present biomechanical data for correct walking through analysis of the gait parameters and COP displacement of the human body before and after wearing the cross-bag cross-bag on the subjects of 29 healthy adult men. The following conclusions were obtained from the analysis result. First, through the analysis of walking parameters using motion analyzer, the speed and Right stride length decreased after wearing the cross-bag, but there showed no significant difference, while Left stride length also decreased after wearing the cross-bag and there showed significant difference. Second, while comparing the COP displacement before and after wearing the cross-bag through the ground reaction force plate, the COP displacement of left-right, front-back after wearing the cross-bag decreased statistically significantly than before wearing the cross-bag. Therefore, when we viewed comprehensively, it is considered that as a result of measuring gait parameter and COP displacement, the more balance change after wearing the cross-bag, the more gait speed is decreased, the smaller stride length is and the COP changes of left-right, front-back also changes. In addition, it is believed that pain and other symptoms will be improved by providing the dynamic muscular strength increase with a significant recovery from the functional state of the patient by making patients with mild lesions such as mild knee arthritis or anterior cruciate ligament do cross-bag gait training.

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