Biomechanical Analysis of Intra-Cycle Gait Structure of Female Athletes

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Abstract: ***This article summarizes the current literature regarding the analysis of walking gait and compared the intra-cycle stages of walking i.e. the difference between selected biomechanical variables in the intra-cycle stages of walking. Five randomly selected female volleyball players aged 18-22 years and who participated in regular physical activity. To analyze the raw data the kinematic variables and stride length Kinovea software was used. Segmentation method was employed in order to assess to the centre of gravity of the body in the time walking stages. The independent t- test was used to measure the difference between two different stages of a complete gait cycle with the selected biomechanical variables. The level of significance was set as 0.05. Result of the study revealed that the step length differs significantly in intra-cycle stages of walking along with shoulder joint. It may be concluded that pattern of physical activity might have an impact on intra gait cycles. The current state of knowledge is presented as it fits in the context of the history of analysis of movement.***

Keywords: Biomechanics, Kinematic, Gait, Stride length, Step length

1. Introduction

Scientific study helps to identify the economy of techniques for better results. Biomechanical or movement analysis is often thought of as just that- the process of observing (measuring) the performance of a skill, identifying faults in the performance and providing feedback to the performer to help correct those fault. Indeed, these steps are part of a biomechanical analysis. The first goal of walking is to move the body forward toward a desired location and at a desired speed. The body does this by moving in as straight a line as possible while moving forward. During walking, the most energy efficient movement is one in which the body moves up and down very little. One way to think about the phases of walking is to think of what happens to each foot when we walk. There are two phases to the normal walking cycle: Stance phase, when the foot is on the ground; and swing phase, when it is moving forward. Sixty percent of the normal cycle is spent in stance phase (25% in double stance with both feet on the ground) and 40% in swing phase. The gait cycle is the basic unit of measurement in gait analysis. Gait cycle is the time between successive foot contacts of the same limbs. Thus, one gait cycle begins when the reference foot contacts the ground and ends with subsequent floor contact of the same foot. Step length is the distance between the heel contact point of one foot and that of the other foot. Stride length is the distance between the successive heel contact points of the same foot. Very few research papers have dealt with the comparative analysis of the intra-cycle stages of a complete gait cycle. External weight added to the body will increase the total body weight and effect the location of the center of gravity of the body and the added weight. *Fred Wilt (1960). Maki BE. (1997)* who dealt with the Gait changes in older adults: predictors of falls or indicators of fear? As well as *Zajac et. al (2002)* dealt with the Biomechanics and muscle coordination of human walking. Thomas, *Corcos and Hasan,* who demonstrated considerable reductions in the dimensionality of kinematic and kinetic data obtained from a whole body movement. In 2005, *Terrier et al.*, by using high accuracy GPS, described low stride-to-stride variability of speed, step length and step duration in free walking. They observed that the constraint of rhythmical auditory signal ("metronome walking") did not alter kinematic variability, but modify the fractal dynamics (DFA) of the stride interval (anti-persistent pattern)

2. Methodology

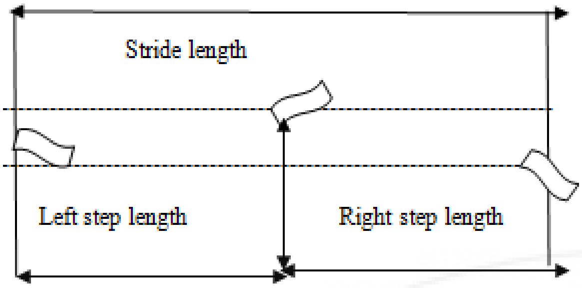
2.1 Protocol

Data concerning five healthy female subjects were selected from volleyball match practice group of Lakshmibai National Institute of Physical Education by using random sampling, with no previous history of gait pathologies and changes, aged 18 to 23 years were collected. Each participant completed one testing session in which biomechanical data were collected while walking over a distance of six meters. Each participant was first asked to walk at her own self selected comfortable pace.

2.2 Selection of variables

The independent variables were selected for the purpose of this study, such as Ankle joint, Knee joint, Hip joint, Shoulder joint, Elbow joint, Wrist joint, Height of centre of gravity at the time of left step phase & right step phase and the distance between left step length and right step length in a complete gait cycle.

2.3 Experimental Set-up and Procedures



Photograph-I Stages of Stride Length

Videography method was used to biomechanically analysis the selected stride length (Left step length and Right step length). Kinovea software was used for biomechanical analysis of intra-cycle stages of female volleyball players. A motor driven, Sony HDR-CX200E camera was used, which was positioned at 5 meters in sagittal plane from the subject at height of 1.4 meter from the subject on an extension of side line of volleyball court. Camera was also set for capturing 50 fps. The subjects were made to walk to six meter along with side line of volleyball court. The video as obtained by the use of digital videography were analysed by Kinovea software. Only one selected frame was analyzed. Selected variables were as under. Were represented by the angles at selected joints as Ankle joint, Knee joint, Hip joint, Shoulder joint, Elbow joint, Wrist joint, Height of centre of gravity at the time of left step phase & right step phase and the distance between left step length and right step length. The step length of the both stages (left and right) of a complete gait cycle of each selected subjects was taken as the criterion measure for the present study.

Photograph-II Stages of step length

2.4 Statistical Analysis

Time and kinematic data of female volleyball players were compared by using the t-test with a significance level of p > 0.05. Kinematic data for the whole group were descriptively compared with similar studies found in literature.

3. Result

Table 1: Descriptive statistics of the different groups

Name of the variables	*Intra-Cycle stages*	*N*	*Mean*	*Std. Deviation*	*Std. Error Mean*
Centre of gravity	Left Step	5	81.6080	6.13703	2.74456
	Right Step	5	80.0700	6.06371	2.71177
Step length	Left Step	5	23.0120	4.51432	2.01886
	Right Step	5	41.7680	7.62680	3.41081
Left Elbow joint	Left Step	5	161.0000	14.56022	6.51153
	Right Step	5	165.0000	12.46996	5.57674
Right Elbow joint	Left Step	5	142.8000	6.18061	2.76405
	Right Step	5	142.4000	9.20869	4.11825
Left Hip joint	Left Step	5	163.0000	8.86002	3.96232
	Right Step	5	161.0000	7.28011	3.25576
Right Hip joint	Left Step	5	165.8000	7.91833	3.54119
	Right Step	5	168.0000	8.68907	3.88587
Left Knee joint	Left Step	5	171.8000	5.93296	2.65330
	Right Step	5	171.0000	5.78792	2.58844
Right Knee joint	Left Step	5	163.0000	5.56776	2.48998
	Right Step	5	162.6000	5.59464	2.50200
Left Ankle joint	Left Step	5	114.2000	6.14003	2.74591
	Right Step	5	108.8000	3.34664	1.49666
Right Ankle joint	Left Step	5	93.2000	6.76018	3.02324
	Right Step	5	89.6000	8.64870	3.86782
Left Shoulder joint	Left Step	5	42.0000	9.74679	4.35890
	Right Step	5	56.6000	10.01499	4.47884
Right Shoulder joint	Left Step	5	63.8000	5.06952	2.26716
	Right Step	5	61.6000	8.20366	3.66879
Left Wrist joint	Left Step	5	140.2000	12.75539	5.70438
	Right Step	5	121.0000	14.31782	6.40312
Right Wrist joint	Left Step	5	131.0000	19.17029	8.57321
	Right Step	5	137.0000	28.85308	12.90349

The values of the mean, standard deviation and standard error of the mean for different kinematic variables and step length are given in the Table 1. The mean intra-cycle stage of the left knee joint (171.80) is larger than that of the other variables. However, whether this difference is significant or not has to be tested by using the two-sample t-test for unrelated groups.

Table 2: F and t-table for testing the equality of variances and equality of means of two unrelated groups

	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Sig.	t	df	Sig. (2-tailed)
Centre of gravity	0.018	0.897	0.399	8	0.701
Step length	4.039	0.079	-4.732	8	0.001
Left Elbow joint	0.398	0.546	-0.467	8	0.653
Right Elbow joint	0.557	0.477	0.081	8	0.938
Left Hip joint	0.155	0.704	0.39	8	0.707
Right Hip joint	0.062	0.809	-0.418	8	0.687
Left Knee joint	0.007	0.936	0.216	8	0.835
Right Knee joint	0.179	0.683	0.113	8	0.913
Left Ankle joint	0.623	0.453	1.727	8	0.122
Right Ankle joint	0.038	0.849	0.733	8	0.484
Left Shoulder joint	0.154	0.705	-2.336	8	0.048
Right Shoulder joint	1.248	0.296	0.51	8	0.624
Left Wrist joint	0.013	0.913	2.239	8	0.056
Right Wrist joint	0.225	0.648	-0.387	8	0.709

*significant at 0.05 level of significance (Tab ‘t’=2.30, df 8)

One of the conditions for using the two-sample t-ratio for unrelated stages of walking is that the variance of the two groups must be equal. To test the equality of variances, Levene's test was used. In the Table 2, F-value of C.G is 0.018. Which is insignificant as the p-value is 0.897 which is more than 0.05. Likewise, all other variables F-value is insignificant, p-value of the variables is more than significance level of p=0.05. Thus, the null hypothesis of equality of variances may be accepted and it is concluded that the variances of two groups are equal.

It can be seen from the Table 2 that the value of the t-statistics is for step length is -4.732. This t-value is significant as the p-value is 0.001 which is less than 0.05. Like that the value of the t-statistics is for Left Shoulder joint is -2.336. This t-value is significant as the p-value is 0.048 which is less than 0.05. Thus, the null hypothesis of equality of population means of two steps of intra-cycle stages of a gait cycle is rejected and it may be concluded that the step length in a single gait is different. In this example only two-tail test was used and therefore, only conclusion which can be drawn is that the different phases or stages in a gait cycle are not equal.

4. Discussion

The objective of the present study was to analysis of walking gait and compared the intra-cycle stages of walking i.e. left step length and right step length of female athletes. Results revealed significant difference with kinematic variables and step length of an intra-cycle stage of walking. The hypothesis as stated earlier that there may not be significant difference between the selected kinematic variables within the intra-cycle stages of walking of female athletes, is rejected in case of step length. In case of kinematic variables, none of the biomechanical variables has exhibited significant differences within the intra-cycle stages of a gait except Left Shoulder joint. This indicates the non symmetrical nature of variables in intra gait stages. But in present study the insignificant result may be due to less sample size, non availability of sophisticated equipment or subjects may not be familiar with the test of intra-cycle stages of walking. This finding is in agreement with others viz. *Thomas, Corcos and Hasan*, who demonstrated considerable reductions in the dimensionality of kinematic and kinetic data obtained from a whole body movement. Gait parameters changed with speed: cadence, step length and stride length all increased with increasing walking speed, while gait cycle duration and the duration of stance decreased with increasing walking speed. Four findings emerged. Reported by *Kepple* hold promise in determining contributions of joint moments to vertical and forward progression of the body's center of mass. *Finch et al. (1991)* studied normal male subject's walking gait under the influence of various BWS levels as compared to full weight support (FWS) gait using a treadmill. As the body weight was systematically removed and walking speed adjusted for BWS levels, the following changes in muscle activity, and mechanical changes in the walk were observed Maki BE. According to *Finch et al. (1991)*, all these observed changes were not significantly different and indicated that BWS could be advantageous in walking gait retraining in normal subjects. Most angular differences of the hip and knee were attributed to harness support and the inability of the subjects to fully plant their foot on the treadmill. In *2005, Terrier et al.*, by using high accuracy GPS, described low stride-to-stride variability of speed, step length and step duration in free walking. They observed that the constraint of rhythmical auditory signal ("metronome walking") did not alter kinematic variability, but modify the fractal dynamics (DFA) of the stride interval (anti-persistent pattern).

5. Conclusion

The present study described the difference between selected kinematic variables in the intra-cycle stages of walking. Finally, we must close the gap between practitioners and biomechanists. It will be important to standardize terminology and to agree on reporting conventions, once new biomechanical knowledge is gained, it is the responsibility of the research community to present it to athletes in an understandable manner. On the whole, the low p-value of significance shown by the variables does not mean that these variables are not contributing to the gait cycle of the subjects in intra-cycle stage. It may be possible that the players have adopted their own style of walking or they do contribute but the insignificant p-value of these variables with the gait may be due to small sample size or it may be due to the sex of athletes. More research should be carried out in relation to biomechanical analysis of different stages in a gait cycle. Since, the results have shown only few significant differences with selected biomechanical variables to the step length and maximum of biomechanical variables showed insignificant, so the hypothesis as stated earlier is rejected in those variables, while other variables (step length and left angle shoulder joint at step length) it is accepted. It may be concluded that pattern of physical activity might have an impact on intra gait cycles.

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