Sport Sciences and Health Research

University of Tehran
Faculty of
Physical Education and Sport Science

The effect of the body type on the electrical activity of the abdominal muscles during gait

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Article Info

Original Article

Article history:

Received: 04 January 2020

Revised: 24 January 2020

Accepted: 1 February 2022

Published online: 1 July 2020

Keywords:
abdominal muscles,
body type,
gait,
muscle activity.

Abstract

Introduction: Muscle performance could be influenced by physical features of the body. The purpose of this study was to investigate the effect of the body type on the electrical activity of the abdominal muscles during gait.

Martials and Methods: Heath Carter somatotype method was used to determine body type. The performance of rectus abdominis muscle (RA), internal oblique muscle (IO) and external oblique muscle (EO) were recorded. The mean and the standard deviation were used for description of the data and ANOVA and post-hoc Tukey were utilized for comparison between three body types at the significance level of $P<0.05$.

Results: The results showed that there is a significant difference in the root mean square (RMS) of EO and IO and the average percentage of that is higher in ENDO in comparison with the other two types. Also, the duration of electrical activity (DEA) was only significant for the IO between the endomorphs (ENDO), the mesomorphs (MESO) and the ectomorphs (ECTO) and its mean was higher for the ENDO.

Conclusion: According to the findings of the study, we could claim that the difference in the performance pattern of the muscles in the abdominal area during gait is influenced by body type.

Cite this article: Ferasat R, Sadeghi H. "The effect of the body type on the electrical activity of the abdominal muscles during gait". *Sport Sciences and Health Research*. 2020, 12(2): 227-233. 10.32598/JESM.12.2.11.

EISSN: 2717-2422 | Web site: https://sshr.ut.ac.ir/ | Email: sshr@ut.ac.ir

 Publisher: University of Tehran, Faculty of Sport Sciences and Health

1. Introduction

There are some influential factors that are related to the cycle of gait such as the size and shape of bones, height, weight distribution on different parts of the body, the amount of movement in joints, and muscular strength [1]. Regarding the validation of the principles related to the effects of anthropometric, biomechanics, and body type factors on optimizing performance of sport activities, it is important to sports science researchers to recognize the role of the aforementioned factors and to utilize them in designing practical activities [2]. Since the aforementioned features varies from one person to another, and the activities of people are influenced by physical features of their bodies, in most studies and researches in the field of Sports Science, the issue of body type has been considered [3, 4, 5, 6].

RA, IO and EO muscles together with the transverse abdominis muscle form the abdominal wall [7]. Continuous activity of the abdominal wall regulates intra-abdominal pressure, which implies a role in breathing [8]. Finally, activity of the abdominal wall contributes to spinal stability [9, 10]. The abdominal muscles provide additional support to the vertebral column by creating tension on the thoracolumbar fascia and increasing intra-abdominal pressure [11], and are generally responsible for maintaining postural stability of the trunk and pelvis and efficiently generating synergistic movements in the vertebral column during a variety of daily activities, especially walking [12, 13]. Abdominal muscles have different patterns of movement and stability [14], and have 55-58% of slow-twitch oxidative fibers. This ability provides the range of various movements from short and quick movements to longer ones in the trunk [15].

Several studies have attempted to verify the roles of the abdominal muscles through electromyography (EMG) recordings during the performance of specific tasks [7, 16, 17, 18, 19], but after reviewing the previous literature, no study was found that explain the duration and RMS of muscles in the abdominal area during gait with attention to different body types. However, it seems that regarding the different body types, the performance pattern of the muscles in this area is different between ENDO, MESO, and ECTO during gait. Therefore, the purpose of this study was to determine the effect of the body type on the electrical activity of the abdominal muscles during gait.

2. Materials and Methods

In this semi experimental study, 18 young men who met the criteria of subject selection and agreed to participate in this study were recruited and divided into three equal groups (ENDO, MESO, and ECTO). Prior to the test, all subjects were briefed on how the test would be administered and how the research project would be conducted. The consent form and the questionnaire related to medical-sports information and personal information including age, height and weight were completed by the subjects. Having no previous injury, history of surgery, or specific illness were some of the conditions the subjects had to meet in order to participate in the study.

Heath Carter somatotype method was used to determine body type [20]. In this method ten anthropometric dimensions are needed to calculate the anthropometric somatotype: height, weight, four skinfolds (triceps, subscapular, supraspinal, medial calf), two bone breadths (biepicondylar humerus and femur), and two limb girths (arm flexed and tensed, calf). In this method, three endomorphic, mesomorphic and ectomorphic scores are obtained for each individual, and the score that is 1.5 units higher than the others is accepted as the body type of each particular subject [21].

The following devices were used for collecting anthropometric data: Seca wall-mounted stadiometer made in Japan with precision to 0.01 mm for measuring the height, Seca digital scale made in Japan with precision to 0.01 mm for measuring the weight, Lufkin flexible measuring tape with precision to 0.01 mm for measuring the limb girths, Mitutoyo caliper made in Japan with precision to 0.01 mm for measuring the bone breadths, and Yagami caliper made in Japan with precision to 0.01 mm and pressure to 10 N/cm^2 for measuring the thickness skinfolds.

The method of obtaining the body type is by means of equations into which the Anthropometric data are entered [20].

Endomorphy= - 0.7182 + 0.1451 (X) - 0.00068 (X^2) + 0.0000014 (X^3)

where X= (sum of triceps, subscapular and supraspinal skinfolds) multiplied by (170.18/height in cm). This is called height -corrected endomorphy and is the preferred method for calculating endomorphy.

Mesomorphy= 0.858 x humerus breadth + 0.601 x femur breadth + 0.188 x corrected arm girth + 0.161 x corrected calf girth – height 0.131 + 4.5

* The correct arm girth is equal to the arm flexed girth subtraction the triceps skinfold divided by 10.
* The correct calf girth is equal to the difference in the maximum calf girth subtraction, the calf skinfold divided by 10.

Three different equations are used to calculate ectomorph according to the height–weight ratio:

If HWR is greater than or equal to 40.75, then **ectomorphy** = 0.732 HWR - 28.58

If HWR is less than 40.75 but greater than 38.25, then **ectomorphy** = 0.463 HWR - 17.63

If HWR is equal to or less than 38.25, then **ectomorphy** = 0.1

* HWR = height / cube root of weight.

Two Kistler force plates made in Switzerland with a sampling frequency of 1200 Hz were used to determine a gait cycle. To do so, the subject's right foot was placed on the first force plate and their left foot was placed on the second force plate. In this study, the gait cycle was defined as the time a subject’s right heel strikes the first force plate until the time when the left toe is removed from the second force plate.

The data on muscle function were collected, using a 16-channel wireless EMG-MYON Model- made in Switzerland with a sampling frequency of 1200 Hz. In this study, RA, IO and EO muscles were identified as the muscles located in the abdominal area [14, 22]. The electrodes were placed between the nerve center of the muscle and the terminal tendon in parallel to the muscle fibers, with a 2 cm distance from the center to the center of the electrodes [23, 24]. The electrodes and cables were fixed on the subjects' body using adhesive tape in order to prevent movement disturbances (Figure 1).

Figure 1. Position of electrodes on the selected muscles

At the earliest stage, which coincided with the end of each attempt by the subject, the EMG signals, check and its initial accuracy were confirmed [25]. The noise from the EMG signals was removed, using a band pass filter between 10 and 500 Hz. The method of Maximum Voluntary Isometric Contraction (MVIC) was used to normalize the RMS. For the duration of the electrical activity, each of the EMG signals was normalized to the maximum of the same signal. EMG signals were processed in a gait cycle using MATLAB software.

Descriptive indices- such as mean and standard deviation of age, height and weight- were used for description of the data. The Shapiro-Wilk test was employed to show the normal distribution of the data, and the ANOVA and post-hoc Tukey were utilized for comparison of different body types at the significance level of $P<0.05$.

3. Results

The demographic characteristics of the subjects are presented in Table 1. There was no significant difference between subjects with regard to age and height but there was a significant difference in the body mass of the subjects.

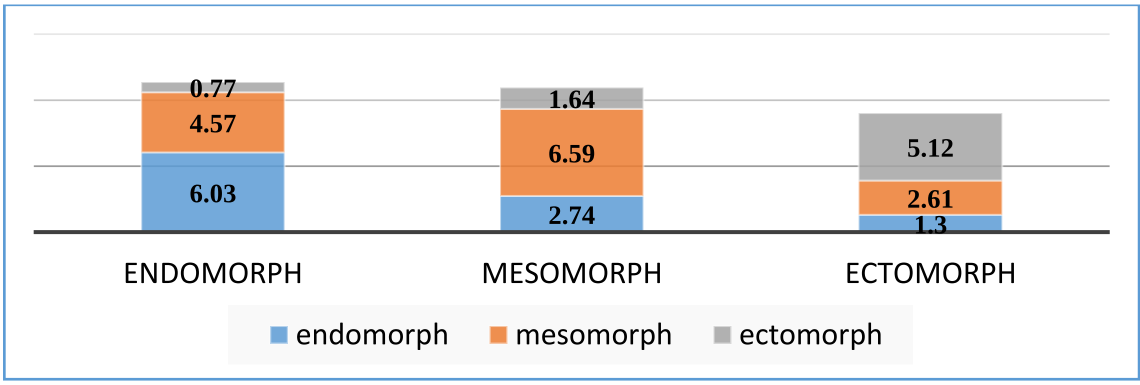
Indices related to the three body types show that ENDO the endomorphic index, MESO the mesomorphic index and ECTO the ectomorphic index were predominant [21] (Figure 2).

The results showed that in the IO and EO, there is a significant difference in RMS between different body types (Table 2).

The results related to the duration of the IO showed a significant difference (Table 3).

Table 1. The general characteristics of the subjects

Body type	Endomorph	Mesomorph	Ectomorph	F	*P*
Age	26.16±2.99	26.33±3.07	24.33±2.42	0.710	0.507
Weight	99.83±14.30	84.33±10.26	63.16±6.27	17.453	0.000*
Height	185.50±6.56	179.83±11.14	183.00±6.09	0.912	0.423



Figure

Figure 2. Body type indices

Table 2. The results of ANOVA for the RMS of the selected muscles

Variable	Muscle	Body type	Mean	Standard deviation	F	*P*
RMS	EO	Endomorph	63.72	9.18	80.243	0.000*
		Mesomorph	12.05	2.28		
		Ectomorph	26.46	8.35		
	IO	Endomorph	56.15	4.52	51.242	0.000*
		Mesomorph	18.27	7.64		
		Ectomorph	29.50	7.35		
	RA	Endomorph	59.49	17.39	3.438	.059
		Mesomorph	35.63	15.27		
		Ectomorph	30.76	26.49		

Table 3. Results of ANOVA for duration of the selected muscles

Variable	Muscle	Body type	Mean	Standard deviation	F	*P*
Duration	EO	Endomorph	578.50	186.36	0.082	0.922
		Mesomorph	546.50	148.76		
		Ectomorph	575.44	222.95		
	IO	Endomorph	673.16	161.63	4.389	0.032*
		Mesomorph	497.16	151.75		
		Ectomorph	463.83	155.53		
	RA	Endomorph	540.16	181.65	2.706	0.099
		Mesomorph	539.16	150.43		
		Ectomorph	789.33	287.36		

4. Discussion

The aim of this study was to investigate the effect of body type on electrical activity of abdominal muscles during gait. Due to the fact that physical characteristics vary from person to person [6], the function of the abdominal muscles can also be affected by the physical characteristics of the body. Therefore, Carter (2002) believes that body type plays a decisive role in human function [20]. The results indicate that there is a significant difference in the RMS of the EO and IO muscles between ENDO, MESO and ECTO during gait. Regarding the duration of electrical activity, a significant difference was observed between the three body types for IO muscle. Also, the average of RMS and duration of electrical activity was higher in EO and IO muscles for ENDO.

The muscles of ENDO, MESO, and ECTO individuals vary in size and volume, leading to different functional patterns of muscles during gait [6]. These differences, due to the mobility pattern of the EO as well as the greater role of stabilization in the IO [14], cause the different muscle torques in this area during gait which have led to the production of different motor units and confirm the existence of significant differences in the electrical activity of these muscles between body types.

Morphological factor or body type is one of the factors affecting balance [26]. There seems to be a direct relationship between balance and electrical activity of the oblique abdominal muscles, which in addition to the role of stabilization, are also effective in lateral movements of the spine during gait [14] according to body type. ENDO have a larger volume in the abdominal muscles and also have a larger body mass than MESO and ECTO; therefore, the reduction of stiffness in the abdominal muscles of these people, which is a characteristic of ENDO, leads to conditions such as muscle imbalance, inadequate and ineffective neuromuscular control, and increased pressure in the intervertebral discs and compressive force in the lumbar vertebrae and eventually the damage increase [27, 28]. Research has shown that ENDO are less balanced during gait than the other body types [6]. Therefore, it seems that having more RMS in ENDO is a compensatory movement pattern to provide better stability and balance during gait, which of course can also cause more metabolism of energy reserves and cause fatigue in the muscles, which can be itself one of the causes of damage in ENDO.

In general, the abdominal muscles have 55 to 58% of the first type of fibers or slow oxidative contraction. Such a capability allows for variety in the production of fast and short movements or long-term movement of the trunk [29]. Slow-motor units of oxidative contraction gently transmit impulses, creating periods of gentle contraction in the muscle. These units produce very little tension, but instead can maintain this tension for a long time. Hence, slow-twitch motor units are useful for maintaining body posture, stabilizing joints, and performing repetitive activities [30]. The pattern of muscle function in abdominal area of ENDO also seems to follow this method, and slow-motor units of oxidative contraction predominated in this area of ENDO. To maintain better balance and prevent falls during gait, the oblique muscles have a longer duration of electrical activity.

5. Conclusion

According to the research findings, it seems that the pattern of abdominal muscles function, which is responsible for maintaining the stability of the trunk and pelvis and creating effective synergistic movements in the spine during various daily activities, especially walking, are influenced by body type.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors contributed to the original idea, study design.

Ethical considerations

The author has completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc.

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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