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ORIGINAL ARTICLE

# Improving physical activity tolerance in sedentary overweight women under beta-alanine supplementation

*Amélioration de la tolérance à l'activité physique chez des femmes sédentaires en surpoids, supplémentées en bêta-alanine*

S. Hooshmand<sup>a</sup>, F. Halabchi<sup>a,b</sup>, A. Hashempour<sup>a</sup>,  
M. Rajabian Tabesh<sup>a</sup>, Z. Alizadeh<sup>a,b,\*</sup>

<sup>a</sup> Sports Medicine Research Center, Tehran university of Medical Sciences, Tehran, Neuroscience Institute, Tehran, Iran

<sup>b</sup> Department of Sports and Exercise Medicine, Tehran University of Medical Sciences, Tehran, Iran

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## KEYWORDS

Beta-alanine;  
Overweight;  
Time to exhaustion

## Summary

**Objectives.** – Today, obesity and inactivity are important health problems in the world and the effective treatments are needed. The aim of the present study was to investigate the effect of beta-alanine supplementation on time to exhaustion and one repetition maximum (1RM) in overweight sedentary women.

**Equipment and methods.** – Forty 20–45-year old overweight female were recruited to the study. The participants were randomized to a beta-alanine supplement ( $n=20$ ) or placebo ( $n=20$ ) group. Body composition was measured by Body Impedance Analyzer. Time to exhaustion was evaluated on the treadmill using the ramp protocol. 1RM was measured for upper and lower extremities by body solid leg press and chest press machines.

**Results.** – Thirty-four participants were analyzed at the end of the study. Change in the time to exhaustion was significant in the intervention group, after 6 weeks ( $P < 0.01$ ). Also, the differences were significant between the two groups ( $P < 0.01$ ). 1RM changes after 6 weeks in upper and lower extremity was not significant within and between groups ( $P = .63$ ,  $P = .23$  respectively).

\* Corresponding author. No. 7, Ale-ahmad Highway, Opposite of the Shariati Hospital, 14395-578 Tehran, Iran.  
E-mail address: z.alizadeh@tums.ac.ir (Z. Alizadeh).

**MOTS CLÉS**

Bêta-alanine ;  
Surcharge pondérale ;  
Délai avant  
épuisement

**Conclusions.** – Based on the results of the present study, six weeks of supplementation of beta-alanine in overweight women increased the time to exhaustion compared to the control group. Such results suggest that natural ergometric agents such as beta-alanine may be helpful for improving the adherence of obese patients to exercise protocols, and that this deserves further investigation.

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**Résumé**

**Objectifs.** – Aujourd’hui, l’obésité et l’inactivité sont des problèmes de santé importants dans le monde, nécessitant des thérapeutiques efficaces. L’objectif de la présente étude était d’étudier l’effet d’une supplémentation en bêta-alanine chez des femmes sédentaires en surpoids sur le temps avant épuisement et sur la répétition maximale (1RM).

**Matériels et méthodes.** – Quarante femmes âgées de 20 à 45 ans en surpoids ont été recrutées pour l’étude. Les participantes ont été randomisées pour recevoir un supplément de bêta-alanine ( $n=20$ ) ou constituer un groupe placebo ( $n=20$ ). La composition corporelle a été mesurée par impédancemétrie. Le temps d’épuisement a été évalué sur le tapis roulant à l’aide d’un protocole de rampe. Le 1-RM a été mesuré pour les membres supérieurs et inférieurs à l’aide des appareils de musculation pour bras et jambes.

**Résultats.** – Trente-quatre participantes ont été analysées à la fin de l’étude. Le temps jusqu’à épuisement était significativement rallongé dans le groupe d’intervention, après 6 semaines ( $p < 0,001$ ). En outre, des différences significatives étaient retrouvées entre les deux groupes ( $p < 0,001$ ). Les modifications de 1-RM après 6 semaines dans les membres supérieurs et inférieurs n’étaient pas significatives à l’intérieur de chaque groupe et entre les groupes ( $p = 0,63$ ,  $p = 0,23$  respectivement).

**Conclusions.** – Sur la base des résultats de la présente étude, six semaines de supplémentation en bêta-alanine chez des femmes en surpoids ont augmenté le délai d’épuisement par rapport au groupe témoin. Ces résultats suggèrent que des agents ergométriques naturels tels que la bêta-alanine pourraient être utiles pour améliorer l’adhésion des patients obèses aux protocoles d’exercice, ce qui mérite une enquête plus approfondie.

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## 1. Introduction

At 2012, the world health organization (WHO) announced that more than 3 million people die every year due to inactivity [1]. Nonetheless existing evidence shows that the level of physical activity in adults is lower than the recommended level [2]. Past studies have shown that during the last half-century, sedentary lifestyle has expanded that leads to an increase in chronic diseases, such as cancers, diabetes or ischemic heart disease, as well as a significant growth in overweightness and obesity rate which is caused by the imbalance of energy intake and expenditure [1–3]. Low activity is not only one of the main factors associated with obesity, but also, physical activity in obese people is also reduced due to obesity complications such as osteoarthritis or decline in their exercise capacity [4,5]. On the other hand, obese people have a lower lactate threshold, and sooner experience peripheral acidosis as well as central fatigue [6].

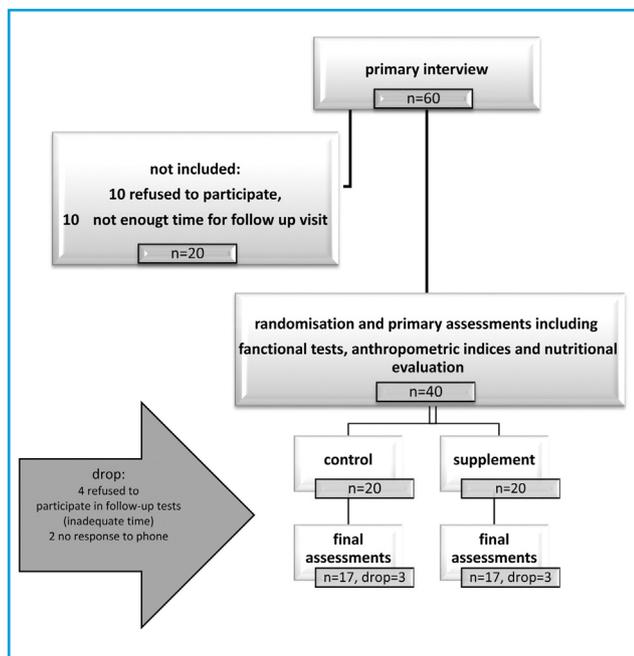
Therefore, any intervention that decreases fatigue, can improve compliance to exercise in obese patients. Beta-alanine is one of these supplements, which is classified in A group by Australian Sports Commission (AIS) [7].

Prior studies have shown that this non-essential amino acid increases intramuscular carnosine levels with 40–80 percent and intracellular buffering as well as regulation of calcium which increase performance especially in physical activities on the upper limit of lactate threshold [8,9].

The effect of consuming beta-alanine as a fatigue resistant supplement was assessed before. Harriss et al, showed that beta-alanine delay metabolic acidosis and neuromuscular fatigue [9]. Major related studies have focused on improving athletic performance in athletes or active people. Since the outcomes of these studies are not applicable to overweight or obese people, the present study aims to determine the effect of beta-alanine supplementation on time to exhaustion and fatigue in overweight women.

## 2. Material and Methods

It was a double blind, randomized, placebo-controlled trial examined the effect of 6 weeks of beta-alanine supplementation on time to exhaustion during exercise in overweight women.



**Figure 1** Flow chart of how participants progressed through the study, and how many contributors completed each stage.

Forty 20–45-year old female with BMI between 25 and 29.9 kg/m<sup>2</sup> participated in this study. Women divided into two experimental groups.

Participants were excluded if they were pregnant, post-menopausal, had uncontrolled diabetes, severe cardiovascular, any neurological or musculoskeletal disorders that would limit the exercise capacity or using any drugs which influence their weight, appetite, heart rate, or ability to perform physical activity. The process of including and excluding participants were presented in Fig. 1.

The participants were randomized to an intervention ( $n=20$ ) or control ( $n=20$ ) group using a table of random numbers.

Intervention group received beta-alanine supplement and placebo tablets were given to the control group. Supplements were made in the form of 800 mg tablets from the GNC Pharmacy Company. Participants in the intervention group took two pills per day (equal to 1.6 g daily) with breakfast and dinner. Participants were asked to continue their routine physical activity and healthy nutrition that was educated by a specialist in the first visit, during the study. The study period was six weeks and in half of which the participants were followed up by telephone, and any ambiguity or question was resolved through telephone counselling by a sports medicine specialist.

Weight, fat mass (FM) and percentage of body fat (PBF) were measured using the Body Impedance Analyzer (AVIS33 body composition analyzer, Jawon Medical Co. Ltd, South Korea) and height was measured by using a standard tape.

The waist circumference was measured by standard tape. The waist circumference was measured immediately above the bony prominence of the iliac crest and the hip circumference at the most prominent part of the buttocks with the minimal dress. Each area was measured twice in turn and in the case of a difference of more than five millimeters

between the two measurements, the process was repeated for the third time. The skin fold thickness was measured on the right side of the body in two abdominal points (5 cm on the right side of the umbilical cord) and superiliac point by the Slim Guide Caliper. The measurement was repeated two to three times and if the difference between the two measurements was more than three millimeters, it was repeated for the fourth time.

Daily food intake was assessed by 24-h food record at the baseline and 6 weeks after intervention. The 24-hour food records were analyzed using the FPI II software (Food Processor II, Nutrition System ESHA Research, Salem, Oregon 1987), which could calculate the consumed calorie, carbohydrate, protein, and fat intake based on percentage and grams.

Time to exhaustion was evaluated on a treadmill using the ramp protocol [10]. The participants were requested to run on the treadmill until to maximal exhaustion.

1RM was measured for upper and lower extremities by Body Solid Leg press and Chest press Machines. After warm-up, participants were asked to do their maximal effort with appropriate weights. If the repetition was greater than twenty, after 5-minute rest, the test was repeated with heavier weights. 1RM was calculated by following formula:  $1RM = (\text{weight lifted}) / (1 - 0.02 * RTF)$ .

At the end of six weeks, the participants were re-visited. They were analyzed by the bio-impedance device. Treadmill testing was performed to determine the fatigue time, as well as strength tests and anthropometric measurements. Their 6-weeks results were compared with previous outcomes.

Measurements were done by the Sports Medicine specialist before and after the intervention.

This research has been approved by the Tehran University of Medical Sciences and Health Services (IRCT registration ID: IRCT201609077903N8). Approved informed consent form was completed by participants.

## 2.1. Statistical methods

The statistical software SPSS 16.0.0 (SPSS Inc. Chicago, IL, USA) was used for all data analysis. P-values less than 0.05 were considered statistically significant. A *t*-test was used to compare the baseline indices at the beginning of the study and paired *t*-test was used to compare the intra-groups outcomes. Also, to compare the change process in two groups, GEE was used.

## 3. Results

Frothy overweight participants were engaged in the study. Participants were randomly divided into two groups (Fig. 1).

### 3.1. Anthropometric measurements

Baseline and changes in anthropometric measurements over time in the two groups are presented in Table 2. The two groups were similar in the parameters evaluated at baseline.

As shown in Table 1, changes in body weight, body mass index, fat percentage, fat mass, waist circumference, abdominal and supra-iliac skin fold in the intervention group

**Table 1** Baseline and changes in anthropometric measurements over time in the two groups.

Variable	Group	Before	After	<i>P</i> -value*	<i>P</i> -value**
Weight (kg)	Beta-alanine	73.07 (4.23)	71.18 (5.3)	.004	.82
	Control	72.27 (4.16)	71.25 (5.1)	.07	
BMI (kg/m <sup>2</sup> )	Beta-alanine	28 (1.7)	27.43 (1.9)	.025	.78
	Control	27.72 (1.4)	27.37 (1.74)	.11	
FAT%	Beta-alanine	35.86 (24)	34.9 (2.9)	.004	.98
	Control	35.55 (2.38)	35.19 (2.47)	.24	
SLM (kg)	Beta-alanine	42.7 (2.5)	42.2 (0.6)	.13	.91
	Control	42.12 (1.8)	42.07 (2.6)	.9	
FM (kg)	Beta-alanine	26.22 (2.6)	24.93 (3.3)	.001	.91
	Control	25.75 (2.8)	25.16 (3.09)	.15	
Waist C (cm)	Beta-alanine	97.96 (4.33)	95.6 (4.41)	<.001	.36
	Control	98.87 (5.09)	97.16 (5.23)	.01	
Hip C (cm)	Beta-alanine	104.5 (4.37)	102.15 (4.85)	<.001	.09
	Control	105.14 (2.95)	104.05 (3.39)	.07	
Abdomen SF (mm)	Beta-alanine	31.18 (6.6)	31.2 (6.42)	<.001	.63
	Control	32.65 (7.9)	31.05 (9.01)	.035	
Supra iliac SF (mm)	Beta-alanine	29.3 (6.9)	27.4 (7.04)	<.001	.5
	Control	30.85 (5.43)	29.2 (4.59)	.068	

The values are expressed as mean (SD), statistical difference  $P < 0.05$ , BMI: body mass index; FAT%: fat percent; SLM: soft lean mass; FM: fat mass; C: circumference; SF: skin fold.

\* Within group.

\*\* Between group.

were significant in 6 weeks, but the differences between two groups were not significant.

### 3.2. Ramp test indices

Functional indicators including the ramp test variables, the time to exhaustion at the start of the study and its trends over the 6 weeks in both groups, were presented in.

The participants in the two groups did not have any significant differences in resting heart rate and ramp test variables, including the time to exhaustion, in the baseline measurements ( $P > 0.05$ ). The changes of ramp test parameters, treadmill speed and incline, maximum heart rate (HRmax) and time to exhaustion were significant in the intervention group, after 6 weeks. Also the differences were significant between two groups.

### 3.3. Strength tests indices

Strength tests indices including upper and lower extremity assessments at baseline and at the end of the study in both groups are presented in Table 3.

The participants in the two groups did not have significant differences in the strength indices including maximum strength of the upper and lower extremities in baseline measurements ( $p > 0.05$ ). Changes after 6 weeks in upper and lower extremity strength indices were not significant within and between groups except for weight L in the beta-alanine group (Table 3).

### 3.4. Results of 24-h food records

In the present study, the mean calorie and macronutrient intake did not differ significantly between the two groups at baseline. Also, there was no significant difference in the changes in the mentioned indices over time in both groups and between groups ( $p > 0.05$ ).

## 4. Discussion

The present study was a double blind, randomized, placebo-controlled trial aimed to evaluate the effect of 6 weeks of supplementation of beta-alanine on the time to exhaustion during dynamic exercise in sedentary overweight female participants. Forty participants entered the study and data from 34 patients were analyzed at the end.

The results showed a significant decrease in weight, BMI, PBF, Waist and hip circumference, abdominal and supra-iliac skinfold in the intervention group ( $p < 0.05$ ). The same changes were not observed in the control group ( $p > 0.05$ ). However, there were no significant differences between the two groups in the mentioned indices ( $P > 0.05$ ).

### 4.1. The effect of beta-alanine supplementation on body composition

There are limited studies regarding the effect of beta-alanine supplementation on the body composition [11–13]. In a study by Hoffman et al, the effect of beta-alanine and creatine supplements was evaluated on college-aged soccer players who were received a strength exercise program for 10 weeks. No changes in weight were observed,

**Table 2** Baseline and changes in Ramp test indices over time in the two groups.

Variable	Group	Before	After	<i>P</i> -value*	<i>P</i> -value**
TTE (min)	Beta-alanine	8.06 (2.24)	8.85 (2.04)	< .001	< .001 <sup>a</sup>
	Control	7.37 (1.19)	7.42 (1.16)	.77	
HR max (beat/min)	Beta-alanine	160.4 (16.3)	164.9 (15.3)	.03	.04
	Control	149.52 (18.42)	150.94 (16.25)	.5	
Speed (km/h)	Beta-alanine	5.31 (1.04)	5.64 (.98)	.001	.02
	Control	4.84 (.44)	4.9 (.46)	.64	
Grade (%)	Beta-alanine	13.17 (1.01)	13.5 (1.23)	.009	.02
	Control	12.53 (.8)	12.7 (.85)	.19	

The values are expressed as mean (SD); statistical difference:  $P < 0.05$ , TTE: time to exhaustion; HR: heart rate, Speed: speed of treadmill, Grade: grade of treadmill.

\* Within group.

\*\* Between group.

<sup>a</sup> Analyzed by ANCOVA (analysis with GEE  $P = .06$ ).

**Table 3** Baseline and changes in Ramp test indices over time in the two groups.

Variable	Group	Before	After	<i>P</i> -value*	<i>P</i> -value**
Rep U (number)	Beta-alanine	4.6 (1.84)	4.2 (1.93)	.08	.95
	Control	4.35 (2.34)	4.65 (2.52)	.5	
Weight U (kg)	Beta-alanine	19.6 (6.11)	22 (7.27)	.06	.56
	Control	17.05 (5.6)	17.05 (5.02)	1	
1RM U (kg)	Beta-alanine	21.65 (6.6)	24.08 (8.07)	.08	.63
	Control	18.72 (6.13)	18.9 (5.8)	.87	
Rep L (number)	Beta-alanine	5.47 (2.5)	4.2 (2.2)	.04	.78
	Control	5.05 (2.63)	4.41 (2.53)	.26	
Weight L (kg)	Beta-alanine	51.6 (17.4)	57 (14.4)	.02	.02
	Control	48.53 (12.47)	50.9 (11.76)	.4	
1RM L (kg)	Beta-alanine	57.93 (19.33)	62.43 (16.23)	.1	.23
	Control	53.8 (12.67)	56.1 (14.39)	.47	

The values are expressed as mean (SD); statistical difference:  $P < 0.05$ ; REP: repeat of chest or leg press; U: upper limbs; 1RM: 1 rep-max; L: lower limbs.

\* Within group.

\*\* Between group.

but a significant decrease in fat percentage was reported in the intervention group compared to the control. In addition, simultaneous consumption of these two supplements improved LMB [12]. However, Abbie et al., showed that after six weeks of supplementation with beta-alanine along with high-intensity interval training (HIIT) in recreationally active men, no significant changes in fat mass occurred, but chronic use of beta-alanine changed LMB significantly [11]. While assessing the beta-alanine supplements on football player and wrestlers showed significant improvement in LMB in intervention group too [14], Kresta et al., found no relation between beta-alanine with or without creatine supplement on body composition of female participants who exercise recreationally [15]. Moreover, beta-alanine along with strength exercise didn't change body composition indices in Asian male physical education students in 10 weeks [13]. In explaining this difference, we must emphasize that in those studies which lead to improvements in LMB, the intervention group was chosen from athletes or active subjects, other supplements such as creatine were prescribed or training protocol consist of strength or HIIT exercise. In the present study, there was no significant change in SLM

within and between groups ( $P > 0.05$ ). The possible cause of this happening is that our study was conducted on sedentary participants and they were asked to do not exercise for 6 weeks with the aim of assessing the effect of beta-alanine alone. As noted above, in the context of the effect of beta-alanine supplementation on other body composition indicators, except Hoffmann and colleagues trial, there was no significant change in fat mass or body fat percentage in the rest of the studies [11]. However, there was some difference between our protocols compare to mentioned studies such as the duration of the intervention, which is longer in our trial. In the present study, fat mass and body fat percentage were significantly decreased in the intervention group, while these changes were not observed in the control group. The duration of the study was also a critical issue. Regarding the process of change, it seems that if the study period was longer, this difference would be significant between the groups.

Overall, based on the outcomes of the present study, it seems that supplementation with beta-alanine may have a positive effect on reducing body fat percentage, but more studies are needed to clarify the effect.

## 4.2. The effect of beta-alanine supplementation on time to exhaustion

In the present study, time to exhaustion was improved in the supplement group (Table 2,  $P < 0.001$ ). Assessing 22 normal-weight, non-athlete women showed that after 6 weeks of supplementation with beta-alanine, time to exhaustion was increased 2.5% significantly without any intervention in daily eating pattern or physical activity [16] which it was in line with Ghasvand et al. trial on male physical education students [17]. They reported that using beta-alanine decrease lactate concentration and time to exhaustion as a result. Moreover, Stout et al. demonstrated that using beta-alanine for 90 days could lead to a significant increase in functional capacity in the overweight older population (male and female) by delaying the neuromuscular fatigue. Same as previous studies participants were asked to maintain their routine in food intake and daily activity [18]. In a 2016 a review that analyzed 23 articles, reported that the average duration of interventions was  $5.2 \pm 1.8$  weeks and the mean dose of prescribed beta-alanine was  $4.18 \pm 3.1$  g/day. Based on the outcomes, supplementation of beta-alanine increases the time to exhaustion, reduces fatigue and improves the biochemical parameters associated with fatigue in athletes and non-athletes. However most of the reviewed studies were performed on athletes (football players, cyclists, etc.) [8]. Along with mentioned studies, our study showed a significant increase in time to exhaustion after 6-week supplementation with beta-alanine. It was mentioned before that there is a direct relationship between higher BMI and lower physical activity levels [19,20]. In a study of Hulens et al., weight gain and high BMI were one of the key factors that increased fatigue perception in the 6-minute walk test [19]. In another study Hulens et al., found that exercise capacity was lower in obese subjects (at maximum and near to maximum severity) compared to lean ones. Furthermore, the anaerobic threshold in obese women was significantly lower than non-obese women [20]. Therefore, it seems that reducing fatigue and increasing the time to exhaustion in such individuals is more important. Increasing time to exhaustion in the present study occurred in a low dose of the supplement. Unlike professional athletes, the level of intramuscular carnosine is low in non-athletes. So the uptake of beta-alanine is higher in this group and they can easily respond to low doses of beta-alanine. [8].

Nevertheless, there are also limited studies that show beta-alanine has no positive effect on the time to exhaustion [21,22]. In a 28-day study, using 1.6 g beta-alanine for 6 days in a row and following the trial by 2–3 g/day did not affect time to exhaustion [22]. Also, in another study after 28 days of supplementation with beta-alanine, there was no significant change in the time to exhaustion, which was measured by the exercise test on a stationary bicycle [21]. The mentioned studies have limitations, including the length of study and the use of the stationary bicycle for evaluating subject's performance that may affect the results due to a relationship with quadriceps strength. In the present study, the duration of the trail was six weeks and based on the hypothesis that overweight patients may suffer from knee pain (due to osteoarthritis) [23] which would disrupt the exercise test with bicycles, ramp test on the treadmill were

used. In addition, such a difference in the results of various studies can be explained by the different capacity of individuals to absorb and use beta-alanine by skeletal muscle [8].

In sum, it seems that taking 6 weeks of beta-alanine supplementation can delay the onset of exhaustion in overweight women without structured exercise. We found that sedentary women may need a lower dose of beta-alanine than athletes or physically active persons to improve performance.

## 4.3. 1RM and strength tests

Based on the present study, changes in the upper and lower extremity 1RM in the groups were not significant (Table 3). Assessing the effect of 30-day supplementation with beta-alanine on bodybuilding athletes showed that it could increase muscular endurance in resistance exercise but couldn't affect 1RM strength [24], which is aligned with our results. But at 2006, Hoffman et al., reported that beta-alanine plus creatine improved strength performance significantly [12] but due to the different exercise protocol and simultaneous use of creatine, comparing the results of this study with the present study is difficult and misleading.

In sum, the beta-alanine supplement could not increase 1RM in overweight women.

## 4.4. Dietary assessment and 24hr food intake

In the present study, at baseline, there was no significant difference in the mean calorie and macronutrient intake between the two groups ( $P > 0.05$ ). The differences between groups after six weeks of intervention were not significant according to statistically analysis ( $P > 0.05$ ), but changes in calorie intake were important by the clinical view. Based on the results, 165 kilocalories from the total daily energy intake by the control group were reduced at the end of 6 weeks. However, such a decrease could explain the 1 kg weight loss in this group. In contrast, there is no reduction in the mean caloric intakes in the supplement group, although a weight loss of 1.9 kg was observed in this group. Since weight loss is a result of reduced dietary intake or increased daily activity, and participants were asked not to start organized exercise during the study period, these changes in body weight may occur due to improvement in daily activities and reducing exhaustion time in the supplement group. However, a single 24 h food record is not a valid assessment method for evaluating changes in dietary intake and further studies with more precise tools is needed.

In sum, it seems that changes in anthropometric indices and time to exhaustion was independent of calorie intake and probably associated with the intake of beta-alanine in the intervention group.

## 4.5. Limitations and strengths

The limitation of our study was the exclusion of male volunteers. However, correlation of participants makes it possible to better generalize the results in this population. Moreover, obese people were not included due to the probability

of musculoskeletal problems during the test. Thus, there is much work remains to be done especially studying on obese peoples. Also, most of the previous studies have been conducted on athletes; further studies are needed to assess beta-alanine possible effects on the general population.

## 5. Conclusion

Based on the results of the present study, six weeks of supplementation of beta-alanine in overweight women increase the time to exhaustion compared to the control group and may also have beneficial effects on anthropometric indices. Longer-term studies with a higher dose of beta-alanine are needed to evaluate the effects of such supplementation on anthropometric indices in female participants.

## Disclosure of interest

The authors declare that they have no competing interest.

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