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Momordica charantia extract supplementation tend to affect improvements in body composition and metabolic parameters on tennis players: A pilot study

Running title: The potential effect of bitter melon intake on body composition and metabolic factors

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Abstract : Dietary supplements derived from natural sources are an essential factor in optimizing athletic performance. It has been proposed that the extract of *Momordica charantia* (*M. charantia*) that is known as a bitter melon can be potentially used as a novel supplement for health promotion. This pilot study aimed to examine the effects of the *M. charantia* extract when administered in the form of a sports drink, and we evaluated changes in body composition and metabolic factors in tennis players after 4-week consumption of the extract. Eight male college tennis players were instructed to consume an *M. charantia* extract 6 times per day (3 in the morning and 3 in the afternoon, and the total daily intake was 600 ml). Collected data were analyzed using paired *t*-tests to examine the changes over time after consumption of the *M. charantia* extract. The results revealed a significant increase in the trunk muscle mass, basal metabolic rate, and daily calorie intake ($p < 0.05$). Levels of protein, minerals, and total body water showed an increased tendency (not statistically significant), whereas intracellular water and extracellular water showed a decreased trend. Furthermore, fat-free mass, skeletal muscle mass, and muscle mass showed an increased tendency. In conclusion, consumption of the *M. charantia* extract caused an increase in parameters related to protein, muscle mass, and metabolism. It seems that

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follow-up studies related to fatigue, inflammation, and stress hormones related to the *M. charantia* extract consumption would be needed.

Keywords : Momordica charantia, Supplementation, Athlete, Body composition, Metabolic factors

1. Introduction

Athletic performance depends on a number of parameters such as physical and physiological factors. Therefore, it is necessary to identify the promising factors that positively affect to optimize performance increments. Accordingly, potential areas of research continue to emerge. Athletes are required to train constantly to optimize their athletic performance; therefore, an ideal body composition is necessary to obtain optimal body movement in high-pressure events [1]. Body composition is representative of the current physical status of an athlete, including their training performance [2]. Relative ratios of body composition are linked to the incidence of injuries and are strongly associated with physical ability [3]. Thus, body composition is the most important parameter for athletes to improve their athletic performance.

Meanwhile, the development of sports drinks containing natural extracts from plants with the aim of improving athletic performance remains a popular research area [4]. *Momordica charantia* (*M. charantia*), commonly known as bitter melon, contains amino acids, saponins, vitamin B1, dietary fiber, iron, phosphorus, potassium, and other minerals and is particularly rich in vitamin C. These extracts boost sugar metabolism, pancreatic function, and energy conversion [5]. Furthermore, they have been reported to positively affect the reduction of blood glucose levels, immune activity enhancement, thirst alleviation, and fatigue recovery; moreover, they are used in dietary therapy and have an antipyretic action [6]. In addition to previous studies of *M. charantia*-induced biological activities, it possess fatty acid oxidation, mitochondrial activity, energy production, adenosine monophosphate (AMP) activity, and AMP-activated protein kinase (AMPK) activity [7]. These characteristics indicate the potential of these extracts for use in sports drinks; however, only few studies supporting the same have been conducted.

This pilot study was conducted to investigate the effects of an *M. charantia* extract administered in the form of a sports drink. The study aimed to analyze the effects of consumption of *M. charantia* extract over 4 weeks on the body composition and metabolic factors of college tennis players. Further, using the derived data, we sought to obtain further basic information to verify the impact of consumption of this extract on the parameters of athletic performance.

2. Methods

2.1. Study subjects

The subjects of this study included 8 elite tennis players, with an average of 5 years (5.4 ± 1.8) of athletic experience, who underwent training (approximately 14 to 19 as per the Rated Perceived Exertion (RPE) scale) for 120 minutes per day for 5 days per week. All subjects participated in this experiment voluntarily with an understanding of the purposes and content of this study. The institutional human research committee approved the research proposal, and the authors followed the guidelines of the Declaration of Helsinki and ethical principles. The study subjects were instructed to abstain from the use of nutritional supplements and medicines for one month prior to the experiment and to continue to avoid the intake of supplements other than the *M. charantia* extract during the experimental period. Physical characteristics of the study subjects are presented in Table 1.

2.2. Study design

This pilot study, which aimed to verify the effects of the *M. charantia* extract, analyzed the changes in the body composition and metabolic factors of the selected tennis players before and after the 4 weeks consumption of the *M. charantia* extract. The test parameters were classified into physical parameters (height, weight, body mass index), cellular body component factors (protein mass, mineral mass, total body water, intracellular water, and extracellular water), muscle-related factors (fat free mass, skeletal muscle mass, muscle mass, left hand mass, right hand mass, left leg mass, right leg mass, and trunk mass), and fat-related factors (body fat percentage, body fat mass, abdominal obesity rate, visceral fat mass, and subcutaneous fat mass). Finally, this study analyzed the metabolic parameters (basal metabolism rate and daily intake of calories).

2.3. Body composition

To accurately measure body composition, the study subjects were instructed to maintain a fasting state and wear casual clothes. The measurements were performed at 8 am, after the removal of all metal items from the body, using bioelectrical impedance analysis (X-Scan Plus II, Jawon Medical, Seoul, Korea).

2.4. *M. charantia* extract sampling and consumption

Four kilograms of raw *M. charantia* and 6,000 ml of water were added to the extractor, and the mixture was heated at 100 °C at a pressure of 0.7 kg/cm^2 for 3 h. The extract was poured into small plastic packs (at a volume of 100 ml), sealed, and stored in a refrigerator. Analysis of the components of the *M. charantia* extract revealed the following results: calories: 0.4 g/100 g; carbohydrates: 0.1 g/100 g; sodium: 10.4 mg/100 g; and vitamin C: 6.42 mg/100 g. Based on the methods described in previous studies published in Korea on natural beverages, in our study, we instructed the subjects to consume the *M. charantia* extract six times per day thrice in the morning and thrice in the afternoon. The total intake was limited to 600 ml per day for a period of 4 weeks.

2.5. Statistical analysis

The data were analyzed using SPSS ver. 21.0 (IBM Corp., Chicago, IL, USA) to calculate the mean (M) and standard deviation (SD) of the measurement items; a paired t-test was performed to determine the differences in body composition before and after the intake of the *M. charantia* extract. Differences were considered statistically significant at p values $<$ 0.05. Effect size (Cohen's d) was used to determine the average change between the data before and after the experiment. We used a standard interpretation of the effect size. (d: $|0.20| \leq$ small $< |0.50| <$ medium $< |0.80| \leq$ large) [8].

3. RESULTS

3.1. Effect of consumption of *M. charantia* extracts on physique

Changes in physical parameters such as height, body weight, and BMI after the intake of the *M. charantia* extract are presented in Table 1. As expected, no statistically significant differences were observed in any parameters related to physique.

3.2. Effect of consumption of *M. charantia* extracts on cellular body component factors

There were no significant changes before and after the supplementations in cellular levels

Table 1. Change of physique parameters after consumption of *M. charantia* extract

Variable	Pre	Post	*t* value	*p* value	Cohen's *d* effect size
Height (cm)	178.38 ± 6.53	178.76 ± 6.47	-1.488	0.180	0.17
Body weight (kg)	73.16 ± 10.77	73.86 ± 10.95	-0.968	0.365	0.19
BMI (kg/m^2)	22.91 ± 2.37	23.01 ± 2.35	-0.382	0.714	0.12

BMI, Body mass index. Values are M±SD. Effect size range: |0.20|≦small<|0.50|, |0.50|<medium<|0.80|, |0.80|≦large.

Table 2. Change of cellular body components after consumption of *M. charantia* extract

Variable (kg)	Pre	Post	*t* value	*p* value	Cohen's *d* effect size
PM	12.58 ± 1.16	12.83 ± 1.16	-2.092	0.075	0.79
MM	4.25 ± 0.61	4.31 ± 0.63	-1.930	0.095	0.29
TBM	43.67 ± 4.51	44.12 ± 4.53	-0.755	0.475	0.28
IW	28.70 ± 3.32	27.46 ± 2.88	0.732	0.488	-0.06
EW	17.33 ± 2.14	16.66 ± 1.67	0.643	0.540	-0.89

PM, Protein mass; MM, Mineral mass; TBW, Total body water; IW, Intracellular water; EW, Extracellular water. Values are M±SD. Effect size range: |0.20|≦small<|0.50|, |0.50|<medium<|0.80|, |0.80|≦large

of body components including protein and mineral mass, total body water, intracellular water, and extracellular water (Table 2). However, Cohen's *d* calculation showed that *M. charantia* extracts had a significant medium and large effect on protein mass (*d* = 0.79) and extracellular water (*d* = -0.89), respectively.

3.3. Effect of consumption of *M. charantia* extract on muscle-related factors

To investigate the influence of consumption of the *M. charantia* extract on whole-body and segmental muscle-related components, we analyzed fat free mass, skeletal muscle mass, muscle mass, left hand mass, right hand mass, left leg mass, right leg mass, and trunk mass (Table 3). In addition, the effect size of *M. charantia* extract on muscle-related factors was calculated using Cohen's *d* calculation. The supplementation of *M. charantia* extract had a medium effect size for fat-free mass (*d* = 0.53), skeletal muscle mass (*d* = 0.78), left leg mass (*d* = 0.66) and right leg mass (*d* = 0.69).

3.4. Effect of consumption of *M. charantia* extract on fat-related factors

We also confirmed distribution of fat-related components including body fat percentage, body fat mass, abdominal obesity rate, visceral fat mass, and subcutaneous fat mass, which are shown in Table 4. No significant differences on the variables were found after the supplementation of *M. charantia* extract. However, Cohen's *d* calculation showed a decreasing trend with a small effect size for %BF (*d* = -0.46), BFM (*d* = -0.23), VFM (*d* = -0.28), SFM (*d* = -0.23).

Table 3. Change of muscle-related factors after consumption of *M. charantia* extract

Variable (kg)	Pre	Post	*t* value	*p* value	Cohen's *d* effect size
FFM	60.13 ± 6.13	61.27 ± 6.31	-2.225	0.061	0.53
SMM	20.75 ± 3.07	29.67 ± 4.07	-2.141	0.070	0.78
MM	56.38 ± 5.58	56.96 ± 5.69	-0.710	0.501	0.30
LHM	3.83 ± 0.40	3.89 ± 0.39	-1.542	0.167	0.43
RHM	3.87 ± 0.42	3.92 ± 0.42	-1.156	0.286	0.33
LLM	10.08 ± 1.01	10.31 ± 1.09	-1.801	0.115	0.66
RML	10.13 ± 0.99	10.37 ± 1.08	-1.945	0.930	0.69
TM	27.92 ± 2.81	28.46 ± 2.79	-3.199	0.015#	0.55

FFM, Fat free mass; SMM, Skeletal muscle mass; MM, Muscle mass; LHM, Left hand mass; RHM, Right hand mass; LLM, Left Leg mass, RML, Right Leg mass; TM, Trunk mass. Values are M±SD, #$p < 0.05$. Effect size range: |0.20|≦small<|0.50|, |0.50|<medium<|0.80|, |0.80|≦large

Table 4. Change of fat-related factors after consumption of *M. charantia* extract

Variable	Pre	Post	*t* value	*p* value	Cohen's *d* effect size
% BF (%)	17.27 ± 4.69	16.51 ± 4.51	1.512	0.174	-0.46
BFM (kg)	13.02 ± 5.36	12.58 ± 5.08	0.878	0.409	-0.23
AOR (%)	0.77 ± 0.05	0.76 ± 0.05	1.426	0.197	-0.00
VFM (kg)	1.61 ± 0.85	1.53 ± 0.72	0.716	0.497	-0.28
SFM (kg)	11.41 ± 4.52	11.05 ± 4.35	0.910	0.393	-0.23

%BF, % Body fat; BFM, Body fat mass; AOR, Abdominal obesity rate; VFM, Visceral fat mass; SFM, Subcutaneous fat mass. Values are M±SD. Effect size range: |0.20|≦small<|0.50|, |0.50|<medium<|0.80|, |0.80|≦large.

Table 5. Change of metabolic factors after consumption of *M. charantia* extract

Variable	Pre	Post	*t* value	*p* value	Cohen's *d* effect size
BMR (kcal)	1650.00 ± 117.62	1666.37 ± 115.80	-2.441	0.045#	0.39
DIC (kg)	2541.00 ± 181.27	2566.12 ± 178.30	-2.434	0.045#	0.39

BMR, Basal metabolism rate; DIC, Daily intake of calorie. Values are M±SD, #$p < 0.05$. Effect size range: |0.20|≦small<|0.50|, |0.50|<medium<|0.80|, |0.80|≦large.

3.5. Effect of consumption of *M. charantia* extract on metabolic parameters

The results of the analysis of the metabolic parameters are shown in Table 5 and Figure 1. The *M. charantia* extract caused a statistically significant increase in basal metabolism rate and daily calorie intake ($p < 0.05$, $p < 0.05$), which is further confirmed by the Cohen's *d* effect size ($d = 0.39$).

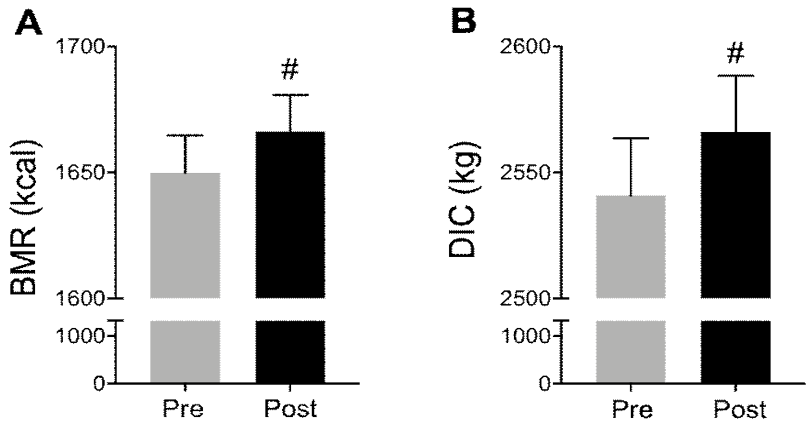

Fig. 1. Effect of 4 weeks of *M. charantia* extract intake on metabolic factors.
BMR (A) and DCI levels (B) were significantly increased between pre and post-trial. All data are presented as M±SD. Paired *t*-test was performed ($^{\#}p < 0.05$). Note. BMR: basal metabolism rate, DCI: daily intake of calorie

4. Discussion and Conclusion

This pilot study evaluated the effects of the *M. charantia* extract on the body composition and metabolic factors of college tennis players. This study is limited as the intake group alone was targeted; moreover, only bioelectrical impedance analysis was selected to measure body composition. However, this study is a significant first step to identify the potential function of the *M. charantia* extract as a supplement to support effective training through optimizing body composition of muscle and fat.

In our study, changes in physical parameters due to *M. charantia* extract intake did not occur (Table 1). These results suggested that the 4 weeks intake of *M. charantia* extract was insufficient to render an effective change in physique; however, the reason for the lack of change in physical parameters should be verified through a more detailed analysis of the change in body composition in particular focusing a cellular body-components level.

In the protein changes that promote the synthesis of protein in the muscles, which can be used as an energy source, we need to focus on the components of the *M. charantia* extract. Previous studies have reported that these extracts contain amino acids and saponins and are involved in the enhancement of energy metabolism through the promotion of mitochondrial activity [9]. The results of our study, which showed an increase in protein levels with medium effect size (Table 2), corroborated the results of these previous studies. Water has been reported to assist the transfer of nutrients required for energy within the body and transport bodily waste out of the body; thus, low water levels may cause edema and inflammation [10]. In our study, a decreasing trend with a large effect size for water was a natural phenomenon resulting from the increase in muscle mass. The analysis of the *M. charantia* extract in this study confirmed that the extract was rich in sodium and vitamin C, suggesting that these two constituents may promote glucose metabolism to enhance protein synthesis.

In the analysis of whole-body and segmental muscle components, all parameters showed an increasing trend with significant effect size (Table 3). These results can be explained by the increase in protein levels inside the body (Table 2). The increase in protein and muscle mass has been regarded as an effect of the components of the *M. charantia* extract; this supports previous research that indicated that the components of these extracts were influential in activating the AMPK via the activation of AMP in myoblasts [11]. The changes in muscle-related parameters identified in this study suggest the need for further studies on factors related to physical fitness.
Fat-related parameters showed an overall decreasing trend, but not significant. These results were a natural consequence of the fact that the study subjects were elite college athletes who maintained high-intensity training and, therefore, had a low percentage of body fat. To analyze the effect of *M. charantia* on body fat, it is necessary to subclassify the subjects and extend the study period. Our results showed an increase in metabolic parameters including basal metabolism rate and daily intake of calorie (Figure 1), and suggested a close relationship with protein metabolism, total body weight excluding fat, and skeletal muscle mass; previous studies corroborated these results, indicating that a high basal metabolic rate may be related to an increase in muscle mass [12]. Ultimately, a high muscle mass influences the basal metabolic rate, which indicates a direct relationship with fat-free mass [13,14]. Previous studies support the results of this study, showing that the basal metabolic rate increased as the fat-free mass increased [15,16]. In this regard, the effects of muscle-related factors would further influence the basal metabolic rate and the daily calorie intake. In this study, intake of *M. charantia* extract expect activated mitochondria and increased energy production.

Thus, the results showed that consumption of the *M. charantia* extract resulted in an increase in body composition parameters related to protein, muscle mass, and metabolism. Consequently, follow-up studies on the effects of the extract on fatigue, inflammation, and stress hormones are required.

Conflict of Interest

The authors declare no conflict of interest.

References

1. A. J. Hector, S. M. Phillips, “Protein recommendations for weight loss in elite athletes: a focus on body composition and performance”, *International journal of sport nutrition and exercise metabolism*, Vol.28, pp. 170－177, (2018).
2. A. A. Aragon, B. J. Schoenfeld, R. Wildman, S. Kleiner, T. VanDusseldorp, L. Taylor, C. P. Earnest, P. J. Arciero, C. Wilborn, D. S. Kalman, J. R. Stout, D. S. Willoughby, B. Campbell, S. M. Arent, L. Bannock, A. E. Smith-Ryan, J. Antonio, “International society of sports nutrition position stand: Diets and body composition”, *Journal of the International Society of Sports Nutrition,* Vol.14, pp. 1－19, (2017).
3. J. Sundgot-Borgen, N. L. Meyer, T. G. Lohman, T. R. Ackland, R. J. Maughan, A. D. Stewart, W. Müller, “How to minimise the health risks to athletes who compete in weight-sensitive sports review and position statement on behalf of the Ad Hoc research working group on body composition, health and performance, under the auspices of the IOC medical commission”, *British journal of sports medicine,* Vol.47, pp. 1012－1022, (2013).
4. C. D. Costley, T. L. Schwenk, “When food becomes a drug: Nonanabolic

nutritional supplement use in athletes", *American journal of sports medicine,* Vol.30, pp. 907-916, (2002).
5. M. S. Hussain, N. Jahan, M. M. Or Rashid, M. S. Hossain, U. Chen, N. Rahman, "Antihyperlipidemic screening and plasma uric acid reducing potential of Momordica charantia seeds on Swiss albino mice model", *Heliyon,* Vol.5, p. e01739, (2019).
6. R. Fachinan, A. Fagninou, M. P. Nekoua, A. M. Amoussa, M. Adjagba, L. Lagnika, A. Lalèyè, K. Moutairou, A. Yessoufou, "Evidence of immunosuppressive and Th2 immune polarizing effects of antidiabetic momordica charantia fruit juice", *BioMed research international,* Vol. 2017, p. 9478048 (2017).
7. Y. Yu, X. H. Zhang, B. Ebersole, D. Ribnicky, Z. Q. Wang, "Bitter melon extract attenuating hepatic steatosis may be mediated by FGF21 and AMPK/Sirt1 signaling in mice", *Scientific reports,* Vol.3, p. 3142 (2013).
8. Cohen J. Statistical Power Analysis for the Behavioral Sciences, 2nd Ed. Hillsdale: Lawrence Erlbaum, (1988).
9. M. Raish, "Momordica charantia polysaccharides ameliorate oxidative stress, hyperlipidemia, inflammation, and apoptosis during myocardial infarction by inhibiting the NF-κB signaling pathway", *International journal of biological macromolecules,* Vol. 97, pp. 544-551, (2017).
10. T. Kofler, M. Bossard, S. Aeschbacher, A. Tabord, F. J. Ruperti Repilado, S. van der Lely, S. Berger, M. Risch, L. Risch, D. Conen, "The interrelationships of birthweight, inflammation and body composition in healthy adults", *European journal of clinical investigation,* Vol.46, pp. 342-348, (2016).
11. G. C. Chen, H. M. Su, Y. S. Lin, P. Y. Tsou, J. H. Chyuan, P. M. Chao, "A conjugated fatty acid present at high levels in bitter melon seed favorably affects lipid metabolism in hepatocytes by increasing NAD+/NADH ratio and activating PPAR α, AMPK and SIRT1 signaling pathway", *Journal of nutritional biochemistry,* Vol.33, pp. 28-35, (2016).
12. A. Chanet, S. Verlaan, J. Salles, C. Giraudet, V. Patrac, V. Pidou, C. Pouyet, N. Hafnaoui, A. Blot, N. Cano, N. Farigon, A. Bongers, M. Jourdan, Y. Luiking, S. Walrand, Y. Boirie, "Supplementing breakfast with a vitamin D and leucine-enriched whey protein medical nutrition drink enhances postprandial muscle protein synthesis and muscle mass in healthy older men", *Journal of Nutrition,* Vol.147, pp. 2262-2271, (2017).
13. S. Gundmi, A. G. Maiya, A. K. Bhat, M. H. Hande, A. S. Kumar, "Screening for basal metabolic rate and visceral fat among postmenopausal osteoporosis with type 2 diabetes mellitus", *Diabetes and metabolic syndrome,* Vol.13, pp. 981-984, (2019).
14. Z. Wang, H. Wu, W. S. Stone, J. Zhuang, L. Qiu, X. Xu, Y. Wang, Z. Zhao, F. Han, Z. Zhao, "Body weight and basal metabolic rate in childhood narcolepsy: a longitudinal study", *Sleep Medicine,* Vol.25, pp. 139-144, (2016).
15. M. P. St-Onge, D. Gallagher, "Body composition changes with aging: The cause or the result of alterations in metabolic rate and macronutrient oxidation?", *Nutrition,* Vol.26, pp. 152-155, (2010).
16. A. L. Woods, A. J. Rice, L. A. Garvican-Lewis, A. M. Wallett, B. Lundy, M. A. Rogers, M. Welvaertv, S. Halson, A. McKune, K. G. Thompson, "The effects of intensified training on resting metabolic rate (RMR), body composition and performance in trained cyclists", *PLoS One,* Vol.13, pp. 1-24, (2018).