Circulating irisin and its connection with indices of body composition in aerobic and anaerobic endurance professional athletes: a case-control study

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Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Background and purpose
Irisin is released in response to exercise, but the regulatory effect of exercise on serum irisin is controversial. Evidence linking irisin with muscle mass or fat mass is limited. Little is known about the connection of irisin with the type and intensity of exercise in athletes. This study sought to determine serum irisin concentration (SIC) in professional athletes and non-athletes and assess its association with anthropometric indices, including body weight (BW), body mass index (BMI), waist-to-height ratio (WHtR), mid-upper arm circumference (MUAC), lean body mass (LBM), and fat mass (FM).

Material and methods
We conducted a case-control study on 72 athletes and non-athletes comprising three age-and sex-matched groups with a 1:1 sex ratio: 24 footballers (aerobic endurance exercise), 24 bodybuilders (anaerobic strength exercise), and 24 nonexercised controls. Standard protocols for measuring anthropometric indices and quantifying SIC were followed.

Results
Whole athletes had higher SIC than controls, with footballer men and women having higher values than bodybuilders and controls. Athletic men and women exhibited higher SIC than control men. SIC showed no sex differences within each experimental and control group. SIC negatively correlated with BW, BMI, LBM, MUAC, and WHtR in athlete women, BMI and MUAC in bodybuilders, FM in whole footballers, and BW in total control, but positively correlated with overall bodybuilders.

Conclusions
The findings indicate that irisin is exercise-dependent, as it is enhanced in aerobic endurance more than in anaerobic strength exercise but is gender-independent. The results also support the relationship between irisin and body composition, as it clearly correlates negatively with BW, BMI, FM, and WHtR, suggesting a possible interplay between irisin and BW homeostasis for health maintenance.

Keywords: irisin, soccer players, bodybuilders, muscle mass, fat mass, body mass index, waist-to-height ratio
Анотация
Муса Нуман Ахмад, Далия Мокхамад Абу Аль Хайджа. Циркулирующий иризин и его связь с показателями состава тела у профессиональных спортсменов с аэробной и анаэробной выносливостью: исследование «случай-контроль»

Цель
Иризин в высокой степени влияет на физическую нагрузку, но регулирующее влияние на уровень иризина в крови вызывает споры. Доказательства связи иризина с выносливостью ограничены. Мало известно о связи иризина с составом тела. В этом исследовании стремились определить концентрацию иризина в сыворотке (SIC) у профессиональных спортсменов и неспортсменов и оценить ее связь с антропометрическими показателями, включая массу тела (BW), индекс массы тела (BMI), соотношение талии к росту (WHtR), окружность середины плеча (MUAC), безжировая масса тела (LBM) и жировая масса (FM).

Материалы и методы
Мы провели исследование методом «случай-контроль» с участием 72 спортсменов и неспортсменов, включающих три группы: 24 футболиста (аэробные упражнения на выносливость), 24 бодибилдеры (анаэробные силовые упражнения) и 24 нетренированных спортсмена. Соблюдались стандартные протоколы измерения антропометрических показателей и количественного определения SIC.

Результаты
У спортсменов в целом SIC был выше, чем у контрольной группы, причем у мужчин и женщин-футболистов значения были выше, чем у бодибилдеров и контрольной группы. Спортивные мужчины и женщины показали более высокий SIC, чем мужчины из контрольной группы. SIC не показал половых различий в каждой экспериментальной и контрольной группе. SIC отрицательно коррелировал с BW, BMI, LBM, MUAC и WHtR у спортсменов, BMI и MUAC у бодибилдеров, FM у футболистов и BW в общем контроле, но положительно коррелировал с обхватом талии и длины тела.

Выводы
Полученные данные показывают, что иризин зависит от физической нагрузки, поскольку он повышается при аэробной выносливости больше, чем при анаэробных силовых упражнениях, но не зависит от пола. Результаты также подтверждают взаимосвязь между иризином и составом тела, поскольку он явно отрицательно коррелирует с BW, BMI, LBM и WHtR, что предполагает возможное взаимодействие между иризином и гомеостазом BW для поддержания здоровья.

Ключевые слова: иризин, футболисты, бодибилдеры, мышечная масса, жировая масса, индекс массы тела, соотношение обхватов талии и длины тела.
Introduction

Irisin is a novel hormone recognized in 2012 [1]. It is released in response to exercise after stimulation of peroxisome proliferator activator γ coactivator-1 alpha (PGC1α), which in turn stimulates the expression of fibronectin type III domain containing 5 (FNDC5) and the proteolysis of this gene produces irisin. Irisin is released from skeletal muscle in mice and humans into circulation targeted toward white adipose tissue as a chemical messenger [1]. Irisin is also considered an adipokine released from adipose tissue [2]. The hormone increases the expression of uncoupling protein 1, resulting in increased thermogenesis, enhanced systemic metabolism, and boosted energy expenditure [3]. Thus, irisin seems promising in controlling chronic disorders such as cardiometabolic disease, obesity, and diabetes [4].

In the context of net energy balance, physical activity intervention has a limited influence on energy expenditure [5]. The main component of energy balance is the resting metabolic rate. However, physical activity has a far greater impact on the net energy balance than the exercise's direct energy cost; thus, exercise may boost the resting metabolic rate [5, 6]. Browning the white adipose tissue by irisin is one of the suggested mechanisms [1].

Sports are classified according to the type and intensity of exercise, into dynamic and static, and based on muscle metabolism, into aerobic and anaerobic [7]. Most high-intensity static exercises, such as muscle building, are performed anaerobically; while high-intensity, dynamic exercises lasting for more than several minutes, like football, are performed aerobically [7]. Although the connection between irisin and exercise has been suggested, the evidence is inconsistent. Several debatable studies that relate irisin to exercise in normal subjects are available [8-14]. Circulating irisin levels did not rise after aerobic endurance training, or with strength endurance training [10, 12, 13]. Cooke et al [8] and Daskalopoulou et al [9] reported that different protocols of exercise raised irisin levels, and Tsuchiya et al [14] suggested that different exercise intensities affected irisin secretion. Kremer et al [11] indicated that prolonged aerobic exercise produces a transient increase in irisin concentrations during the first hour for both genders. The different experimental protocols, gender, age, body composition, and genetics are among the reasons for the present controversy. Muscle mass is responsible for about 80% of energy expenditure, and irisin is proposed to increase energy expenditure, suggesting an interchangeable relationship between muscle mass and irisin [15]. Muscle mass is also affected by the type of exercise, and high-intensity anaerobic exercise is responsible for the anabolic process that leads to muscle hypertrophy, a critical adaptation in muscles for optimal performance [16]. Circulating irisin levels decrease as body mass index (BMI) decreases in normal and obese individuals [17]. However, the connection between irisin and indices of body composition, including body weight (BW), BMI, waist circumference (WC), hip circumference (HC), waist-hip ratio (WHR), waist-to-height ratio (WHtR), mid-upper arm circumference (MUAC), lean body mass (LBM), and fat mass (FM) among athletes and non-athletes is generally lacking.

Purpose: to determine serum irisin concentration in non-athletes and professional athletes who regularly engaged in aerobic and anaerobic sports and assess its association with anthropometric indices of body composition, including BW, BMI, WC, HC, WHR, WHtR, MUAC, LBM, and FM.

Material and methods

Participants and study design

A case-control study was undertaken and included three groups of healthy Jordanian men and women aged 20–35, performing aerobic endurance exercise, strength endurance exercise, and not performing any exercise. The study sample (72 participants, 36 men, and 36 women) included three age-and sex-matched groups with varying levels of physical activity. The first group was 24 participants (12 men and 12 women) who following their habitual lifestyle and physical activity and were not performing any regular exercise regimens (unexercised status: 1 hour a week of regular activity for at least one year) as described elsewhere [10]. The participants were recruited from office workers who usually came to their job by car. The second and the third groups, each of which were also 24 participants (12 men and 12 women) and were regularly performing for at least one year either dynamic aerobic endurance
exercise, i.e., aerobic high intensity and long-duration exercise, or strength endurance exercise, i.e., static anaerobic high-intensity exercise [18]. The second group was professional football players who were regularly training for 90 minutes every day, three times a week (Jordan Football Association, personal communication, 2022) and were recruited from among the professional players of the Jordan Football Association, Amman-Jordan. The third group was professional bodybuilders who were regularly training for 90 minutes every day, six days a week (Jordan Bodybuilding Federation, personal communication, 2022), and were recruited from among the professional players of the Jordan Bodybuilding Federation, Amman-Jordan.

Inclusion criteria included: age 20 to 35 years, non-smokers, non-pregnant and non-lactating women, taking no medications or medicinal herbs, and having no diseases or abnormalities that would interfere with exercise or require regular medication, including heart, kidney, thyroid, and respiratory problems, diabetes mellitus, and iron deficiency anemia [10]. Any participant who did not fit the inclusion criteria was excluded. The study was approved by the Institutional Ethics Committee. All participants provided written informed consent before their involvement in the study. The investigator interviewed each participant to obtain information regarding their personal, social, and health history to affirm the inclusion and exclusion criteria. The investigator was also authorized to refer to each player's medical records to check their health condition to see if it did fit the inclusion criteria.

**Ethical policy**

This research included humans and therefore has been provided in accordance with principles embodied in the Helsinki Declaration.

**Data collection**

The investigator interviewed each participant for data collection, including personal information and anthropometric measurements. The BW, height, BMI, HC, MUAC, LBM, and FM were evaluated following standard methods of anthropometry [19]. The weight was measured with light clothing and without shoes to the nearest 0.1kg using a measuring scale, and height was recorded to the nearest 0.5cm using a stadiometer. The WC was measured standing to the nearest 5mm at a level midway between the lower rib margin and the iliac crest during the normal end-expiratory phase. The HC was measured at the level of the greater trochanters. The MUAC was measured on a straight left arm, mid-way between the tip of the shoulder and the tip of the elbow. The BMI was calculated as BW (kg) divided by height (m²), WHtR was obtained by dividing the WC by height, and WHR was computed as the WC divided by HC. A Harpenden skinfold caliper (British Indicators Ltd., England) was used to measure the skinfold thickness of two body sites from which body fat and LBM were calculated according to the regression equations of Durnin and Womersley, 1974 [20]. Systolic (SBP) and diastolic (DBP) blood pressure were measured twice using a standardized mercury sphygmomanometer after seating the subject for at least 15 minutes, and then the average blood pressure was recorded [19].

**Serum irisin determination**

Blood samples (5ml) were collected from each participant following an overnight fast (10–12 h) and 24 hours of not performing any exercise by a licensed phlebotomist in a sitting position according to a standard protocol. Serum was obtained using a serum separator tube. Samples were allowed to clot at room temperature for 30 minutes before centrifugation for 20 minutes and stored frozen at -20°C until analysis. Serum from each participant was processed in one batch for irisin concentrations using standard biochemical kits and the ELISA (catalog # K4761-100, 100 assays. Biovision, S. Milpitas Blvd., Milpitas, CA 95035 USA) assay method.

**Statistical analysis**

Data analysis was performed using statistical analysis software (SPSS Inc., version 19.0.1, Chicago, USA) and processed using ANOVA followed by a Tukey post hoc test. Results were presented as means ± standard error of the mean (SEM). Significance was set at p <0.05. Pearson correlations were used to test the relationship between anthropometric measures and serum irisin concentrations.

**Results**

Table 1 shows the anthropometric measures and blood pressure of athletic and control men and
women. Men of both athletics and control groups had the highest height and were significantly different (P≤0.05) from women of both groups but were insignificantly different (P>0.05) for the entire group.

Athletic men had the highest BW, BMI, MUAC, LBM, and HC and were significantly different (P≤0.05) from other study groups. These variables of total athletics were (P≤0.05) higher than those of overall control. The highest FM was that of the control women and significantly different (P≤0.05) from other study groups. On the other hand, FM was insignificantly different (P>0.05) when comparing total control to total athletics. Control men had the highest WHR and were insignificantly different (P>0.05) from athletic men and women but significantly different (P≤0.05) from control women. No significant difference (P>0.05) in WHR existed between total control and total athletics.

Athlete men had the highest WtHR and were insignificantly different (P>0.05) from other study groups except for control women. Whole athletics had significantly (P ≤0.05) higher WtHR than total control. Athlete men had higher (P≤0.05) SBP than overall athletics and control women. The highest DBP was that of athlete women and insignificantly differed (P>0.05) from that of control men. The DBP and SBP were insignificantly different (P>0.05) between total athletics and total control.

### Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Footballers</th>
<th>Bodybuilders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men n=12</td>
<td>Women n=12</td>
<td>Men n=12</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>174.6 ±1.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>160.9 ±1.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>178.3 ±1.9&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>67.9 ±2.5&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>56.2 ±1.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>74.2 ±2.3&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.2 ±0.6&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>21.7 ±0.5&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>23.3 ±0.4&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>MUAC (cm)</td>
<td>28.4 ±1.0&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>26.4 ±0.8&lt;sup&gt;ad&lt;/sup&gt;</td>
<td>29.3 ±0.6&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Body fat mass (Kg)</td>
<td>9.90 ±0.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.5 ±0.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.5 ±0.8&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lean body mass (Kg)</td>
<td>57.9 ±2.0&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>42.7 ±1.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>63.7 ±1.9&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>82.4 ±2.2&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>72.3 ±2.6&lt;sup&gt;c&lt;/sup&gt;</td>
<td>82.2 ±1.5&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>HC (cm)</td>
<td>95.2 ±1.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>95.3 ±1.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>98.8 ±1.4&lt;sup&gt;bc&lt;/sup&gt;</td>
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<tr>
<td>WHR</td>
<td>0.87 ±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.76 ±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.83 ±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>WtHR</td>
<td>0.47 ±0.01&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>0.45 ±0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.46 ±0.01&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>124.3 ±3.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>107.9 ±2.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>127.1 ±2.9&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>83.8 ±3.0&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>74.3 ±3.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>78.5 ±2.2&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Notes: Data are given as mean ± SEM. Means in rows with different superscript are significantly different (P≤0.05). Abbreviations: BMI: body mass index; MUAC: mid upper arm circumference; WC: waist circumference; HC: hip circumference; WtHR: waist to-height ratio; WHR: waist to-hip ratio; SBP: systolic blood pressure, DBP: diastolic blood pressure.
Table 2 shows group-gender serum irisin concentrations of the study groups. Footballer women had higher (P≤0.05) serum irisin (0.290±0.010 mcg/ml) than bodybuilder men (0.210±0.009 mcg/ml) and control men (0.200±0.008 mcg/ml) and women (0.220±0.009 mcg/ml) but insignificantly different (P>0.05) from both footballer men (0.260±0.014 mcg/ml) and bodybuilder men (0.250±0.011 mcg/ml). Serum irisin concentrations did not show gender differences within each experimental and control group.

Table 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Footballers</th>
<th>Bodybuilders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men n=12</td>
<td>Women n=12</td>
<td>Men n=12</td>
</tr>
<tr>
<td>Serum irisin (mcg/ml)</td>
<td>0.200±0.008 a</td>
<td>0.220±0.009 b</td>
<td>0.260±0.014 a</td>
</tr>
<tr>
<td></td>
<td>Men n=24</td>
<td>Women n=24</td>
<td>Men n=24</td>
</tr>
<tr>
<td>Serum irisin (mcg/ml)</td>
<td>0.250±0.011</td>
<td>0.210±0.007</td>
<td>0.250±0.011 a</td>
</tr>
</tbody>
</table>

Note. Data are given as mean ± SEM. Means in rows with different superscript are significantly different.

Table 3 presents serum irisin concentrations of athletic and non-athletic subjects of the study. Serum irisin did not differ (P>0.05) between athlete men, athlete women, and control women or between control men and women. Serum irisin of athlete men and women was significantly higher (P ≤0.05) than those of control men. The highest mean value of serum irisin was that of athlete men (0.260±0.009 mcg/ml). The respective mean values of control men, control women, and athlete women were (0.200±0.008, 0.220±0.009, and 0.250±0.010 mcg/ml). The overall athletics had significantly (P=0.000) higher serum irisin (0.250±0.007 mcg/ml) than the total control (0.210±0.006 mcg/ml).

Table 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Athletics</th>
<th>Total Athletics n=48</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men n=12</td>
<td>Women n=12</td>
<td>Men n=24</td>
</tr>
<tr>
<td>Serum irisin (mcg/ml)</td>
<td>0.200±0.008</td>
<td>0.220±0.009</td>
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</tr>
<tr>
<td>Serum irisin (mcg/ml)</td>
<td>0.250±0.010</td>
<td>0.210±0.006</td>
<td>0.250±0.007</td>
</tr>
</tbody>
</table>

Note. Data are given as mean ± SEM. Means in rows with different superscript are significantly different.

Serum irisin concentrations in the overall control, footballers, and bodybuilders are shown in Table 4. Footballers had the highest serum irisin and were significantly different (P≤0.05) from both bodybuilders and control. The respective serum irisin mean values for the footballer, bodybuilder, and control groups were (0.280±0.009, 0.230±0.008, and 0.210±0.006 mcg/ml).

Table 4

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total control n=24</th>
<th>Total footballers n=24</th>
<th>Total bodybuilders n=24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum irisin (mcg/ml)</td>
<td>0.210±0.006 a</td>
<td>0.280±0.009 b</td>
<td>0.230±0.008 b</td>
</tr>
</tbody>
</table>

Note: Data are given as mean ± SEM. Means in rows with different superscript are significantly different.

Table 5 shows the Pearson correlations between serum irisin concentrations anthropometric indices and blood pressure in the study sample. Serum irisin positively correlated with height in the whole bodybuilder group (r=0.498, P≤0.05) and negatively correlated in the entire control group (r=-0.44, P ≤0.05). A significant negative correlation existed between serum irisin and BW in athlete women (r=-0.545, P≤0.01) and total control (r=-0.432, P ≤0.05). The BMI of athlete women negatively correlated with serum irisin (r=-0.698, P≤0.01). The MUAC negatively correlated with serum irisin in bodybuilder women (r=-0.826, P ≤0.05) and athlete women (r= -0.431, P≤0.05), whereas positively correlated with this variable in total bodybuilders (r=0.494, P≤0.05). Serum irisin negatively correlated with body FM in overall footballers (r=0.433, P≤0.05). Furthermore, serum irisin negatively correlated with LBM and WHtR in athlete women (r=-0.636, P≤0.01), (r=-0.422, P≤0.01), respectively. The DBP negatively correlated with serum irisin in footballer women, athlete women, and overall athletes (r=-0.676, P≤0.05, r=-0.322, P≤0.05 and r=0.432, P≤0.05, respectively). No correlations were found between serum irisin and other studied variables.

Table 5

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Athletics</th>
<th>Total Athletics n=48</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Women n=12</td>
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<td>0.260±0.009</td>
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<td>0.250±0.007</td>
</tr>
</tbody>
</table>

Note. Data are given as mean ± SEM. Means in rows with different superscript are significantly different.

*P value significant at 0.05 levels donates significant difference between total athletics and total control.
Discussion

Serum irisin concentrations between footballer men and women and bodybuilder men did not differ significantly, and footballer women had the highest value. Insignificant differences were also seen between bodybuilder men and women and control women and between bodybuilder women, control women, and control men. In this study, gender did not affect irisin concentrations, which is consistent with other studies that encountered no significant main or interaction effect of gender on the irisin [21, 22]. It was also found that the circulating irisin of men and women are almost similar [17, 23]. However, after adjusting for LBM, Anastasilakis et al [24] found that males had lower irisin levels than females. Huh et al [25], on the other hand, found that male adolescents had a higher increase in irisin levels following acute swimming than female adolescents. The discrepancy in these results could be attributed to the individuals’ varying ages, sample sizes, and experimental protocols. The participants in this study were between the ages of 20 and 35. Huh et al [22] used middle-aged women, while Stengel et al [17] omitted those under the age of 18, and Huh et al [25] included adolescents as participants. Moreover, a small sample size of elite taekwondo competitors (7 males and 6 females) and college students (8 males and 6 females) between the ages of 16 and 20 were the participants in a recent study [21].

Irisin concentrations were substantially higher in the entire athletes than in total controls. This study is possibly the first case-control study to compare serum irisin in professional athletes and regular active people. Arikan et al. [21], using a small sample size, reported that irisin levels are exercise independent. On the other hand, other studies examined the levels of irisin in the athlete population and revealed a connection between irisin levels and exercise and considered irisin to be one putative mediator of the positive effects of exercise on the metabolic profile [23]. The results of the numerous studies in the literature presented in the debate frequently lack a suitable control group sample size, necessitating an interpretation and partial downsizing of their findings.

Almost all previous study designs were intervention training programs, with the subjects' pre-
exercise intervention serving as the control group. The current research, which included professional Jordanian athletes in two different sports, reveals that irisin may be an exercise-related hormone. Our findings are consistent with Bostrom et al [1], who found that exercise can promote irisin expression in human muscle and blood. As a result, irisin has been proposed as a potential treatment drug for metabolic disorders [1]. Another study also suggested that children and adults both have an acute and brief rise in blood irisin levels after short bursts of intense exercise but not after sustained increases in physical activity [26].

There are significant inconsistencies in the results of several studies looking at irisin and its association with exercise. Type, intensity, and duration of exercise, age, gender, and sample size, along with other lifestyle factors, such as energy intake, diet quantity and quality, nutritional status, and body composition, as well as different experimental protocols and the genetic factor, are among the many potential confounders that may contribute to this discrepancy. Some investigations have agreed with the findings of the current study. Daskalopoulou et al [9] looked at the post-to-pre-exercise variations in irisin levels after a maximal relative and absolute workload exercises and found that serum irisin increased after three workloads. Cooke et al [8] also discovered comparable results. Irisin levels increased at the end of interventional exercise [24]. Huh et al [22] found that circulating irisin levels rise in response to exercise. Norheim et al [12] found that in pre-diabetic participants compared to controls, plasma irisin levels increased initially 45 minutes after exercise and then dropped after 2 hours of rest in an intervention study. Huh et al [25] investigated the influence of exercise intensity on serum irisin levels in high- and moderate-intensity swimming in teenage boys and girls. Circulating irisin levels were shown to peak immediately after high-intensity interval exercise and then fall 1 hour later [25]. Irisin levels were also higher in men and women during the first hour following exercise [11].

On the other hand, other research yielded mixed results. Compared to previously untrained women, no changes in serum irisin were seen following 12 weeks of intense strength training [27]. Serum irisin was measured after 1 hour of low-intensity aerobic exercise, heavy-intensity resistance exercise, 21 weeks of endurance exercise, and a combination of endurance and resistance exercise [13]. The majority of the participants were men of various ages and BMIs. There were no substantial changes in serum irisin after any procedure [13]. Irisin levels were also not enhanced following training [10]. In this study, Jordanian athletes participated in two different sports, football and bodybuilding. Footballers and bodybuilders were compared to one another and to a control group. Footballers had the highest serum irisin levels and were considerably higher than bodybuilders and controls. This result indicated that aerobic endurance exercise, but not anaerobic resistance strength exercise, could change circulating irisin levels, which go in line with that of Bostrom et al [1]. Serum irisin increased 2-fold following ten weeks of aerobic endurance training exercise compared to the non-exercised state [1]. These findings are consistent with Huh et al. [22], who found that plasma irisin decreased after eight weeks of anaerobic intermittent sprint training. Endurance-trained athletes were found to have higher concentrations of circulating irisin than sedentary controls [28]. Furthermore, Ellefsen et al [27] reported similar results.

The result of the present study is inconsistent with those of [13], who have observed no changes in irisin levels after 21 weeks of combined endurance aerobic exercise and resistance exercise. Norheim et al [12] observed that plasma irisin levels acutely increased 45 minutes after aerobic exercise of ergometer cycling and then decreased after 2 hours of rest in pre-diabetes subjects vs. controls but declined after 12 weeks of training. On the other hand, Huh et al [25] reported that serum irisin increased after high-intensity interval exercise in an adolescent swimmer who depended on an anaerobic system, and it did not increase after moderate-intensity aerobic exercise. In the same study, eight weeks of sprint training significantly induced irisin biomarkers FNDC5 and PGC1_ mRNA levels [25]. Tsuichiya et al [14] suggested that irisin is affected by the intensity of exercise as it increased after high-intensity anaerobic exercise but not after low-intensity aerobic exercise. Several reports indicated that circulating irisin was also influenced by the method of analysis used [1, 12, 22], a matter that could be responsible for the dissimilarity in the results of different studies. The muscle phenotype could also be another confounding factor. Ellefsen et al [27] observed that FNDC5 expression is related closely to aerobic muscle fibers,
the myosin heavy chain 2X isoform (MyHC2X) but not with 2A isoform (MyHC2A), which increased in response to strength training. Participants in the present study were all healthy with normal BMIs. Participants who were overweight BMIs were bodybuilders with high lean body mass and not high-fat mass. However, subjects enrolled in the Huh et al [22] study; their BMIs were all above 37 kg/m2, while those of Stengel et al [17] had a wide range of BMIs. Nevertheless, irisin, a new myokine, has recently been linked to human exercise-induced changes in oxidative stress and antioxidant defense, and its concentrations were unaffected by increased training volume or intensity [29].

The present study also investigated the correlations between serum irisin levels and several anthropometric indices. Irisin positively correlated with height in the bodybuilders' group and negatively in the control group. Serum irisin levels showed a strong negative correlation with body weight and BMI in athlete women and a negative correlation with body weight in the control group. Conversely, much research showed that irisin positively correlated with body weight and BMI [17, 22, 27, 30]. This controversy could be due to the differences between subjects enrolled in different studies. While the participants in the present study were all healthy with normal BMI, participants in previous studies were obese [17, 22]. Obese subjects could have insulin resistance. Stengel et al [17] reported a positive correlation of serum irisin with insulin. The increase in irisin levels in the obese subject could indicate a physiological function to improve glucose intolerance and insulin sensitivity, which is often impaired in obese subjects [17]. These results highlight the crucial role of physical exercise in reducing the risk of many chronic diseases and related mortality and morbidity [31-33].

The MUAC is an indicator for muscle mass, and irisin correlated positively with MUAC in bodybuilders and athlete women, while it was positively correlated in total bodybuilders. These results merit further investigations. The positive correlation for irisin with MUAC in total bodybuilders agrees with that of Huh et al [22]. In this study, irisin negatively correlated with MUAC and LBM in athlete women. Similarly, Ellefsen et al [27] reported a positive correlation between LBM and irisin in untrained women, and this correlation seemed to disappear in trained women after 12 weeks of strength training. Ellefsen et al [27] explained this result that strength training could affect the regulation of irisin secretion in skeletal muscle and is likely to be linked to the complex biological induction imposed on muscle cells by training. Stengel et al [17] and Ellefsen et al [27] reported positive correlations between body fat mass and serum irisin, while the present study showed a negative correlation between irisin and body fat mass in footballers. These differences could be due to different exercise habits, as irisin may interact with fat cells resulting in its removal from the bloodstream [27]. In the present study, a negative correlation was observed between serum irisin and WHtR, which is consistent with that reported elsewhere [30]. No correlation was obtained between serum irisin and WHR, which accords with the finding of Stengel et al [17].

One limitation of the present study is the small sample size, and the sample was a convenient one. The timing of sampling could affect the results. Anastasilakis et al [24] have reported that irisin levels followed a day-night rhythm with a peak at 9:00 pm. In this study, all samples were collected before training. The prime feature of this study is that it is possibly the first case-control investigation to compare serum irisin concentration in professional athletes and regular active people.

Conclusions

Taken together, the current findings point to regular exercise training as a means of inducing irisin in the general population. Irisin appears to be a hormone linked to physical activity, and gender did not affect it. The data confirm the theory that the type of exercise can impact circulating irisin, as footballers had the highest levels of irisin. Aerobic endurance exercise or dynamic sports may enhance serum irisin levels more than strength training or static sports. The control group and the participants of the static sport were not statistically different. The complex pattern of inter-group variation in correlations between irisin and anthropometric indices suggests a complex relationship between body composition and regulation of serum irisin and the complexity of understanding irisin biology. The particular negative associations between irisin and BW, BMI, FM, and WHtR also support the possible role of irisin in BW homeostasis for health maintenance.
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