Original article

# Blood glucose response to two intensities of physical exercise in young women during fasting

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**Summary**

**Introduction:** Physical exercise in the fasting state has been a controversial topic; however, some studies have shown a greater loss of body fat and better glycemic control in those who participate in aerobic training when fasting.
**Aim:** To evaluate the glycemic response after a session of moderate or vigorous physical exercise in young women in the state of fasting.
**Material and method:** A randomized clinical trial was carried out. Twenty-six women (19 to 22 years old) were randomly assigned to two intervention groups. The first group was trained at an intensity of 70% of maximum heart rate (MHR) for 30 minutes, and the second group at an intensity of 90% MHR for 15 minutes. Height (cm), weight (Kg), body mass index (BMI), fat percentage, and maximum oxygen consumption ($VO_{2max}$) during a stress test were evaluated. Blood glucose levels were checked before and after the exercise session of each group.
**Results:** No significant changes were found in post-exercise blood glucose levels in any experimental group, and the existing differences were not statistically significant.
**Conclusions:** Moderate or vigorous physical exercise during fasting did not show significant variations in blood glucose, which suggests that it is safe for healthy young women to train when fasting.

**Key words:**
Exercise. Blood glucose. Athletic performance. Body composition.

## Respuesta de la glucemia frente a dos intensidades de ejercicio físico realizado en ayunas en mujeres jóvenes

**Resumen**

**Introducción:** La práctica de Ejercicio Físico (EF) en estado de ayuno ha sido controvertida; no obstante, algunas investigaciones evidencian mayor pérdida de grasa corporal y mejor control glucémico en quienes participan de entrenamiento aeróbico en estado de ayuno.
**Objetivo:** Evaluar la respuesta de la glucemia después de una sesión de ejercicio físico de intensidad moderada o vigorosa realizado en ayunas en mujeres jóvenes.
**Material y método:** Se realizó un ensayo clínico controlado aleatorizado. Veinticuatro mujeres (19 a 22 años) fueron asignadas de manera aleatoria a dos grupos de intervención. El primero fue sometido a una intensidad de ejercicio del 70% de la Frecuencia Cardíaca Máxima (FCM) durante 30 minutos y el segundo a una intensidad del 90% de la FCM durante 15 minutos. Se evaluaron la talla (cm), peso (Kg), índice de masa corporal (IMC), porcentaje de grasa y consumo máximo de oxígeno ($VO_{2máx}$) mediante una prueba de esfuerzo. Los niveles de glucemia fueron determinados antes y después de la sesión de ejercicio de cada grupo.
**Resultados:** No se encontraron cambios significativos en los niveles de glucosa en sangre post ejercicio en ningún grupo experimental, y las diferencias existentes no fueron estadísticamente significativas.
**Conclusión:** El ejercicio físico moderado o vigoroso en estado de ayuno no mostró variaciones significativas en la glucemia posterior a su ejecución, lo que sugiere seguridad en el desarrollo del entrenamiento en ayuno en mujeres jóvenes saludables.

**Palabras clave:**
Ejercicio. Glucemia. Rendimiento atlético. Composición corporal.

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# Introduction

The recommendations issued by specialised organisations, declare the benefits of physical activity (PA) for health, as mentioned by Cenarruzabeitia[1] *et al* (2003); Cadore[2] *et al* (2005); Bayego[3] *et al* (2012). Key benefits include the control of blood glucose levels, thanks to increased sensitivity to insulin and an increase in the number of non-insulin dependent receptors, which ultimately reduces the risk of suffering from metabolic chronic diseases in the future[4,5]; yet, not everyone recognises these benefits[6,7].

Specifically, physical exercise (PE) performed in the morning is one of the most widely used routines by the general public; it offers additional benefits such as a greater loss of body fat when performed before eating any food. Among the physiological reasons for this phenomenon, mention is made of the low levels of insulin and high levels of`plasma epinephrine present during exercise, which is associated with increased lipolysis and peripheral fat oxidation[8-9].

Van Proeyen[8] *et al* (2010) indicate that training while fasting improves the muscle oxidative capacity and increases the use of lipid fuel during aerobic activities, without altering the carbohydrate oxidation (CHO), preventing hypoglycaemia. However, it is important to emphasise the need to eat food the night before, in order to guarantee an appropriate reserve of glucose when starting the training session. Another benefit reported in the literature reviewed, is the one referred to by Stannard[9] *et al* (2010), who concluded that not only does regular exercise reduce the risk of insulin resistance, this is also the case when performed on an empty stomach.

When PE is performed without a full glycogen reserve, due to fasting, then the glycemic values may be balanced by hepatic glycogenolysis or gluconeogenesis, depending on the intensity and duration of the physical activity[8-12]. The carbohydrate energy intake during low intensity effort levels (30% $VO_{2max}$) is around 10 - 15% and its uptake increases by three to four-fold when maximal or supramaximal activities are performed, where the greatest energy input is derived from phosphagen, blood glucose and muscle glycogen[13].

The percentage of energy provided by the blood glucose at intensities of 25%, 65%, 85% $VO_{2max}$ is around 10% and, apparently, its post-exercise variation is not significant after performing activities at intensities of between 46 to 65% $VO_{2max}$ with a duration of ≤ 120 min[13-15].

Finally, the goal of this investigation is to analyse the glycemic response to PE performed during fasting, taking into account the recommendations for the type of exercise, as well as the recomendations for the "moderate or vigorous" intensities issued by the OMS, the American College of Sports Medicine, the American Heart Association and the British Association of Sport and Exercise Sciences for the young adult population[16-17].

# Material and method

A controlled randomized clinical trial was conducted with two parallel intervention groups. An allocation ratio of 1:1 was used.

## Participants

The population comprised students from the physiotherapy course at the University of Santander, women, adults, and residents of the metropolitan area of Bucaramanga, who voluntarily agreed to take part in the study, after reading the informed consent. The inclusion criteria were voluntary participation, to be of legal age, no relative or absolute contraindication for PE. For this purpose, use was made of the self-completion questionnaire *Physical Activity Readiness Questionnaire* (PARQ&YOU), of the Canadian Society of Exercise Physiology[18]. The study excluded those participants showing bone and joint pain during the exercise session (n=1), thoracic discomfort (n=1), gastroenteritis (n=1) and for having had breakfast (n=1), (Figure 1).

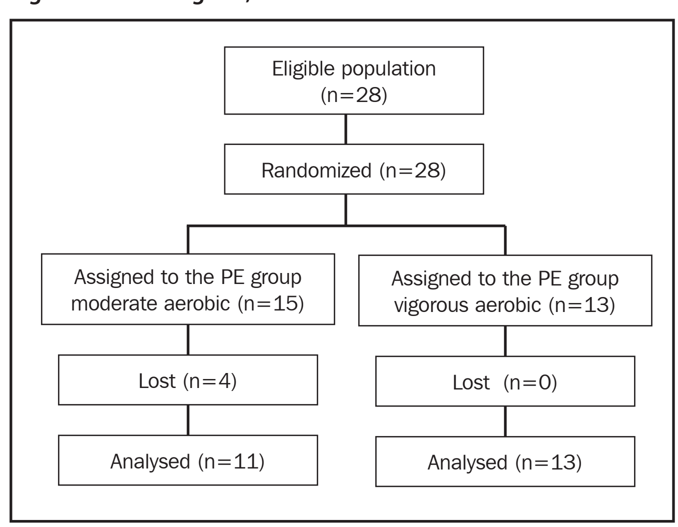
The eligible population were 24 women, who were divided into two groups by simple randomisation, using the Epiinfo 6.04d software. The program allocated 15 women to the moderate aerobic PE (GO) group and 13 to the vigorous PE (G1) group. No masking was performed.

## Procedure

The study was divided into three phases:

- During the first week, the goals of the study were communicated, voluntary participation was requested and the informed consent was signed by each of the participants.
- During the second week, the anthropometric assessment was made, and the aerobic physical capacity through the "yo-yo" test[19].
- In the third week, the randomised allocation of the intervention groups was carried out: (G0) and (G1); the intervention was developed, by taking the blood glucose level before and after PE. On the other hand, it is important to clarify that there was no control of the diet on the night and during the week before the intervention.

**Figure 1. Flow diagram, data collection**




Source: the authors.

## Interventions

The 24 participants performed a single physical exercise session, with a continuous run at 6.30 am.. The (G0) included a 5 minute warm up, 30 minutes of exercise at 70% of the Heart Rate Reserve (HRR) according to Karvonen[20], controlled by heart rate monitors (Polar, Sounto, Omrom) and 5 minutes recovery; the GI performed the same process with an exercise intensity of 90% of the HRR according to Karvonen, for 15 minutes.

## Measurements

### *Anthropometric measurement*

For the height measurement, a standard height rod was used with a scale in centimetres (cm) and millimetres (mm) and with a reading accuracy of 0.1 cm. The body weight was also recorded with digital weighing scales with an accuracy of 100 grams, in order to finally calculate the body mass index (BMI). Additionally, 6 skin folds were taken (triceps, subscapular, suprailiac, abdomen, anterior thigh, calf) using the Harpenden Skinfold Caliper, with a scale accuracy of 0.2 mm, in order to determine the percentage of body fat, using the Yuhasz equation[21]. All measurements were taken following the ISAK standards.

### *Quantification of blood glucose levels*

2 samples of blood glucose levels were taken, before and after exercise, at the index finger tip, with a blood glucose monitor Fast-Check® (Laboratorios DAI, Colombia). This device does not require code calibration or electronic chips.

### *Statistical analysis*

The data obtained were entered in Excel, the database obtained was exported to Stata 13.0 for subsequent analysis. For the numerical scale, central tendency and dispersion measurements were calculated according to the distribution of the variables and, for the nominal scale measurements, the absolute and relative frequencies were calculated. The difference between measurements was compared between groups using the Student t-test for independent data; while the intra-group comparison of the change in blood glucose levels before and after the intervention was made using the Student t-test for paired data. An alpha level of 5% was considered for the entire analysis.

## Ethical considerations

The authors declare that the procedures followed comply with the ethical standards of the committee responsible for human experimentation and in accordance with the World Medical Association and the Declaration of Helsinki.

This study was approved by the investigation committee of the Physiotherapy Program of the University of Santander. The study observed the ethical principles of confidentiality, beneficence, nonmaleficence, autonomy and justice. The authors obtained the informed consent of the patients and/or subjects mentioned in this paper. This document is held by the corresponding author.

# Results

As shown in Table 1, the average age of those performing moderate Pe was 20 years, and those performing vigorous aerobic PE was 21 years. The average BMI was 23.4 (kg/m²), the % of fat, 27.5%, the $VO_{2max}$ 35.4 ml.kg min, pre-exercise blood glucose level 89.1 mg/dl and post-exercise 93.1 mg/dl.

By comparing the changes in the pre and post exercise blood glucose levels in the two groups "PE moderate aerobic and PE vigorous aerobic" no statistical significant differences were found in the initial blood glucose level ($p$=0.701), and the final blood glucose level ($p$=0.611) nor in the differences between the initial and final blood glucose levels ($p$=0.673). On the other hand, with regard to the intra-group comparison, no statistically significant differences were found before and after the intervention of the Moderate PE group ($p$=0.177) or the vigorous PE group ($p$=0.416) (Table 2).

**Table 1. Baseline evaluation of the study population, according to intervention group.**

| Variable | Moderate PE (n=11) | Vigorous PE (n=13) | Overall (n=24) |
|---|---|---|---|
| Age (IQR) | 20 (19-21) | 21 (19-21) | 20 (19-21) |
| Height (mt) | 1.61 ± 0.1 | 1.58 ± 0.1 | 1.59 ± 0.06 |
| Weight (Kg) | 62 ± 11.8 | 58.3 ± 4.5 | 59.8 ± 8.6 |
| BMI (kg/m²) | 23.6 ± 3.8 | 23.2 ± 2.8 | 23.4 ± 3.2 |
| % Fat | 28 ± 7.9 | 27.2± 5.1 | 27.5 ± 6.4 |
| $VO_{2max}$ | 35.4 ± 3.9 | 35.5± 3.1 | 35.4 ± 3.5 |
| GluPrePE | 88.4 ± 5.8 | 89.6 ± 9.1 | 89.1 ± 7.6 |
| GluPostPE | 95.2 ± 13.3 | 93 ± 10 | 93.1 ± 11.6 |

IQR: Interquartile range. BMI: Body Mass Index. GluPrePE:Blood glucose level pre exercise GluPostPE: Blood glucose level post exercise

**Table 2. Blood glucose level before and after exercise in the study population, according to study group.**

| Variable | Moderate PE n=11 | Vigorous PE n=15 | *p* Value |
|---|---|---|---|
| Initial blood glucose level (mg/dL) | 88.4 ± 5.8 | 89.6 ± 9.1 | 0.701* |
| Final blood glucose level (mg/dL) | 95.2 ± 13.3 | 93 ± 10 | 0.611* |
| Difference blood glucose level initial-final(mg/dL) | 6.8 ± 15.5 | 3± 13.1 | 0.673* |
| *P* value (Comparison initial and final evaluation) | 0.177** | 0.416** | |

*t-test for independent samples. **t-test for paired data.
Source: the authors

# Discussion

In this study, the type and levels of intensity of the PE were based on the recommendations issued by institutions specialising in exercise sciences for this type of population[16-17]. The results show that PE performed with either moderate or vigorous intensity levels in fasting conditions, does not generate changes in the blood glucose levels immediately after PE, which is consistent with most studies reviewed[21-25].

One of the reasons to account for the limited variation in the post-exercise blood glucose level for the two experimental groups (G0= 6.8±15.5; G1=3±13.1), is argued by the compensation produced by the hepatic glycogenolysis and the gluconeogenesis, which could be promoted by fasting, which causes increases in the release of glycerol considered to be a valuable pioneer in the development of these processes[26-28].

Ferreira A[14] *et al* (2016) and Van Proeyen[29] *et al* (2013) indicate that one of the possible reasons to account for the fact that the glucose blood level does not decrease, is that the PE performed while fasting, stimulates the production of energy through the oxidation of fat, which means that those persons training in this condition reduce their body fat to a greater extent, without significantly affecting the concentration of glucose in the blood. However, it is important to emphasis that, when lipids gain importance in energy production, physical performance tends to decrease[30].

Another possible reason to account for the non-variation in the blood glucose level immediately after exercise performed when fasting, is the low consumption of glucose of all body tissues at that time, except the muscle and liver[12]. It is also important to stress that, although exercise can increase insulin sensitivity and the transport of glucose to the muscle, this effect may be lessened by the above mentioned lipolytic responses, as well as the anti-glycemic hormonal responses caused by the fasting condition, characterised by an increase in catecholamines, cortisol, growth hormone and glucagon, which controls 70% of the production of glucose during exercise, stimulating glycogenolysis, a process which is more important when the glycogen reserves are depleted due to prolonged exercise or in starvation conditions[26,31,32].

It is important to consider that most of the studies published on the subject use exercises with intensities not greater than 70% $VO_{2max}$, with a duration of less than 120 minutes, therefore the results presented in this study must not be extrapolated as long term effects, where the probability of hypoglycemia could increase[26].

Despite the results of this study and the evidence with regard to the accelerated effect on the oxidation of fat when PE is performed when fasting, it is necessary to clarify that these effects were observed in fit and/or healthy persons. Therefore, precaution should be taken for this type of training for sedentary persons[21,22,26,29].

# Conclusion

The non-existence of changes in the blood glucose level following a moderate intensity physical exercise session for 30 minutes or vigorous intensity for 15 minutes, suggests safety in the performance of a training session of this type for young, healthy women.

## Limitations

The analysis method used to evaluate the concentration of glucose could be considered to be a limitation in our study, given the fact that the glucometer could have a margin of error of between 10 - 15%. However, its use is understandable, as it was for field work. Despite the fact that most of the studies reviewed evaluate this variable by using venous or arterial blood samples. Finally, other limitations observed were the size of the sample used and the failure to control the food eaten the night or week before. For this reason, it is suggested that, for future analyses, a representative sample is included, the control of the dietary variables and the evaluation of glycomia in  the long term, in order to confirm the health benefits or consequences of this type of practice when extended over time.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## Conflict of interest

The authors have no conflict of interest whatsoever.

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