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# Implementation of nutrition care process in Indonesian athletes and its effect on nutritional status and aerobic capacity performance

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## ABSTRACT

**Introduction:** Despite the critical function of a nutritionist, only a few sports training centres for students in Indonesia have one. This study aimed to determine the effect of the nutrition care process (NCP) on athletes' nutritional status and aerobic capacity performance. **Methods:** This cohort study was conducted in 2022 (May–August) in four training centres (TC) in Indonesia. Subjects were athletes who have been dwelling in TC for at least three months, excluding those absent for >14 days due to a competition or other commitments during the data collection period. NCP included the assistance of trained sports nutritionists. In total, 114 athletes participated in this study: 90 strength athletes and 24 endurance athletes. The participants were aged 14-19 years old with approximately *(mean±SD)* 6±2.5 years of experience in specific sports. **Results:** After three months of NCP, knowledge of nutrition ($p$=0.013), body fat composition ($p$<0.001), skinfold thickness scores ($p$<0.001), and performance ($p$<0.001) of athletes significantly improved. In spite of good intakes of protein and fat, none of the intakes showed significant changes ($p$>0.05). Furthermore, improved knowledge of sports nutrition and exercise science had a positive impact on dormitory meal choices. **Conclusion:** Overall, three months of NCP had a significant effect on athletes' knowledge of nutrition, body fat composition, skinfold thickness, and also $VO_2$Max.

**Keywords:** athlete, nutrition care process, sports

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## INTRODUCTION

The nutritional needs of young athletes exceed those of non-athletes. Adequate nutrition is important to meet their daily training demands and for the continuation of other daily activities such as attending school. Generally, the nutrition problems of young athletes are diverse. These include the female athlete triad, iron deficiency anaemia, underweight, obesity, and gastrointestinal disorders (Cabral *et al.*, 2022). Nutritional diagnosis is established according to individual problems, which can be identified based on the results of nutritional assessment. Therefore, sports nutritionists aim to design ideal individual nutrition plans based on the nutrition care process (NCP), of which determining the nutrition problems among young athletes is key to the process.

Nutrition plans should be specific, especially in terms of the type and timing of meals and snacks based on training and competition. Thus, maintaining regular meal patterns preserves lean body mass and replenishes glycogen. Nascimento *et al.* (2016) showed that providing four individual nutrition counselling sessions over a period of eight months improved daily water intake and meal frequency (three hours apart), which could prevent gastrointestinal distress (Nascimento *et al.*, 2016). It also significantly improved the athletes' mid-arm muscle circumference and their body mass before and after the intervention. Another study showed that nutrition intervention could be an effective strategy to improve athletes' behaviours, eating habits, nutrition knowledge, and body composition (Fahrenholtz *et al.*, 2023). A case control study reported that six weeks of nutrition intervention in athletes positively altered their overall body composition, including body fat by 1% and the ratio of mass to fat by 0.3 (Rosimus, 2018).

Daily nutrient intake has a strong influence on athletes' performance and many studies have explored the effects of nutrition interventions. A recent study by Rossi *et al.* (2017) showed an improvement in athletes' performance on the 5-10-5 shuttle run, accompanied by a reduction in fat mass during the 12-week nutrition intervention (Rossi *et al.*, 2017). Evidence shows that good knowledge of nutrition is associated with better diet quality (Fahrenholtz *et al.*, 2023). In this case, the role of a nutritionist as an educator is important, ensuring that athletes receive trusted information. A systematic review on nutrition education in athletes found that 17 out of 22 papers included a nutritionist or dietitian in their research (Boidin *et al.*, 2021). This means that nutritionists and dietitians have an important role as educators for athletes.

Although the importance of nutrition interventions for young athletes has been well established, the role of sports nutritionists in sports schools and training centres in Indonesia is limited. Some studies in Indonesia found that the absence of nutritionists affected athletes' nutrition knowledge, resulting in unhealthy dietary habits (Dewinta *et al.*, 2022). Additionally, even if the athletes already have good nutrition knowledge, they might not implement it into their dietary habits. Athletes' adherence to nutrition advice was found to be seasonal due to the emotional obstacles of a high-performance environment, limiting their opportunity to develop their meal plans (Bentley *et al.*, 2021). We suggest that the implementation of NCP in athletes will improve education about nutrition, body composition, and performance. Thus, this study aimed to evolve an evidence-based approach to the impact of a three-month nutrition care process (NCP) on the body composition, nutrition knowledge, and performance of young athletes in Indonesia.

## MATERIALS AND METHODS

### Ethics and design

This was a prospective cohort study among Indonesian youth athletes in four regions of Indonesia (Capital City Jakarta, West Java, West Nusa Tenggara, and Special Region Yogya). Data collection took place in May–August 2022. Ethical clearance was obtained from the Medical and Health Research Ethics Committee, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Indonesia (KE-FK-0512-EC-2022).

### Participants

The total number of athletes is described in Figure 1. The inclusion criteria were athletes between 14 and 19 years old who had been living in the training centres in those four regions for at least three months prior to the initial data collection. The exclusion criteria were injury or sickness that disallowed active training, or athletes who had a competition at another location, requiring them to leave the training centre for >14 days. At the beginning of the study, 274 athletes were enrolled. Some subjects failed to complete the study because they were required to take time off to compete at another location. Additionally, some of the participants graduated from school and left the dorm, while other athletes were unable to follow the full programme due to ill health. At the end, the total number of subjects involved in this research was 114 athletes.

### Intervention

The intervention employed in the present study consisted of placement of nutritionists or dietitians at each training centre for three months. During this period, nutritionists and dietitians were responsible for conducting NCP for athletes, which was established in 2021 (Penggalih *et al.*, 2021). The athletes were given intervention in the form of a nutritional guideline programme. The assessments carried out in this study included body fat, body muscle, skinfold, and daily nutrient intake.

The interventions provided included meal assistance, training assistance, and nutrition-related education for athletes. Nutrition education was carried out in large and small groups. Large-group education provided information related to nutrition for different types of sports and hydration. Small-group education provided information regarding portion sizes. The tools used for large-group education were modules that contained nutrition information, while a nutrition profile containing dietary recommendations for each athlete was used for small-group education. NCP was carried out by a sports nutritionist. The number of sports nutritionists in each region was dependent on the number of athletes, with a ratio of 1 sports nutritionist per 30 athletes.

### Measurements

In the present study, changes in athletes' performance were based on data on maximal oxygen uptakes ($VO_2$ max-ml/kg-min). $VO_2$ max was measured using the Balke and Bleep test. To define, the Balke test was running for 15 minutes, then the test results were adjusted to existing norms (Herdiles, Cholil & Komarudin, 2017). Meanwhile, the Bleep test, which is also known as a shuttle trial or Yo-Yo, was running back and forth from one point to another, which were placed 20 meters apart on a flat surface. This running test used the software sound "beep" as a sign that athletes start running and touch another point, at least one foot. This test

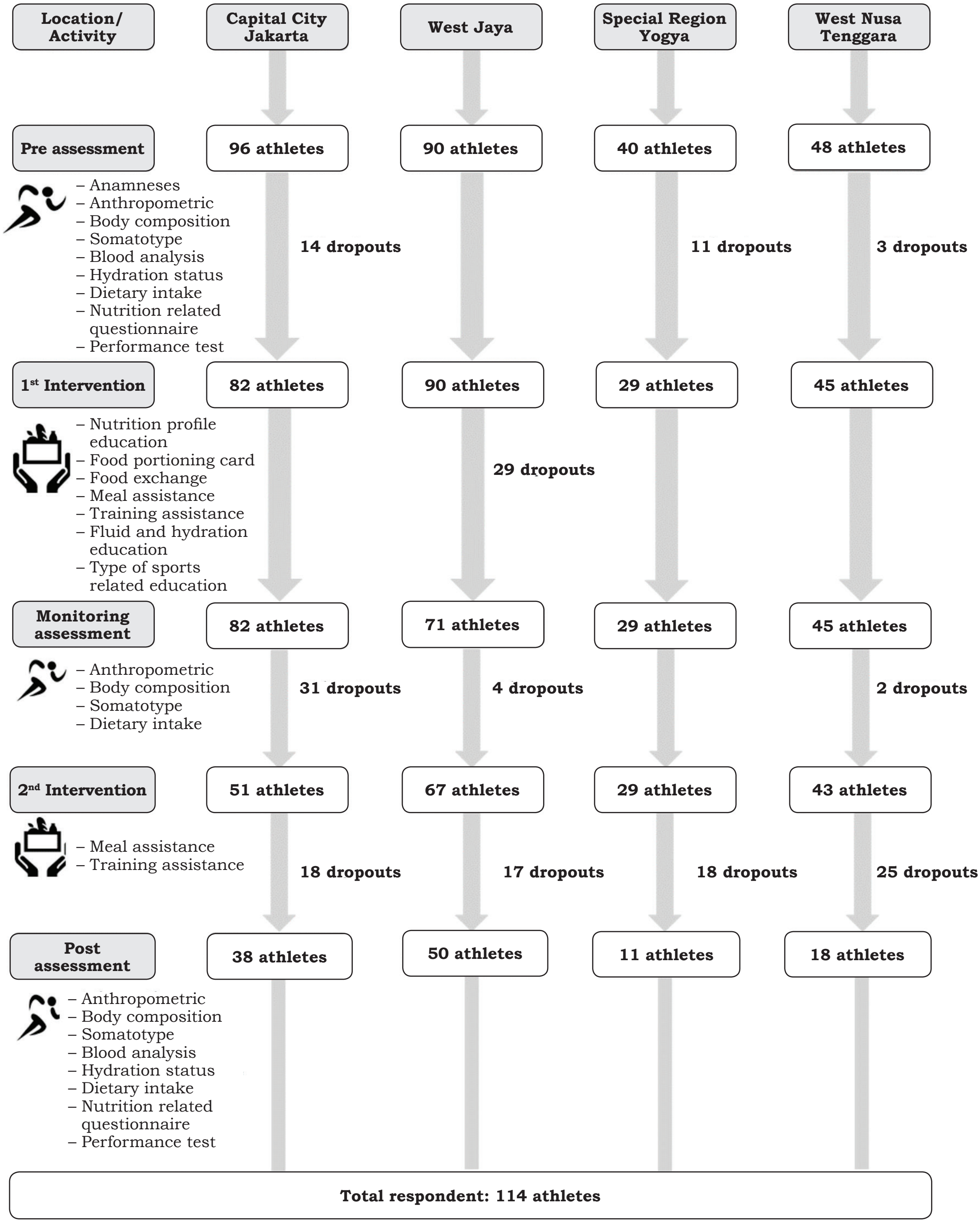


**Figure 1.** Data collection flow

consisted of 21 levels in which the "beep" tone became sooner. The score was decided by the accomplished level and the number of shuttles (total running) that were reached before they failed to adjust to the "beep" sound (Buttar, Saboo & Kacker, 2019). Aerobic capacity measurement used two methods for verification; this was essential because several athletes lived scattered across Western, Central, and Eastern Indonesia. Hence, to get valid data, the Bleep and Balke test methods were used. The tests were conducted at the beginning and at the end of the study by coaches.

The nutritional status of athletes included body fat (%), body muscle (%), skinfold (mm), fulfilment of nutrient intake compared with nutrient adequacy (%), and score of nutrition education. Body fat and body muscle were measured via bioelectrical impedance analysis (BIA) using OMRON Karada Scan HBF-375 (Omron, China) with 0.01 kg precision. Skinfold was measured using a Harpenden skinfold calliper (0.1 mm precision). BIA and skinfold measurements were taken in the morning after the athletes woke up (around 6.30 am). In this study, fat-free mass was measured with BIA and skinfold. Using both measurements provided a more accurate and comprehensive look at fat distribution. Measurement with BIA was used to see the distribution of total fat, while skinfold was used to describe the distribution of fat on specific parts of the body, such as the triceps, subscapular, suprailiac, and calf (Penggalih *et al.*, 2021).

Nutrient intake was measured by two methods - visual food Comstock and SQ-FFQ (semi-quantitative food frequency questionnaire). The former was used to quantify the percentage of dorm food intake obtained by comparing the ingested food to the individual portion recommendation. Individual nutritional needs were calculated based on the Recommended Dietary Allowance (RDA) from the Ministry of Health Indonesia 2019. The latter was to measure the intake of non-dorm foods (Penggalih *et al.*, 2021). All activities were collected directly by the sports nutritionists in each dormitory. Nutrition education was evaluated with questionnaires both prior to and after the intervention programme. Meal assistance was provided to ensure that athletes were eating the correct portions and small group discussions were used to convey the information. Meal assistance was carried out once per month for three main meals and two snacks. Nutritionists matched the meal recommendations with the portions that athletes took at the eatery. If their portion sizes were inappropriate, athletes were encouraged to adjust the portion of food according to their needs.

Training assistance was carried out to evaluate patterns of fluid consumption during exercise. Before and after training, athletes measured their body weight to monitor changes. The athletes were also questioned about the amount of fluid consumed during exercise.

**Protocol**

The study began with recruiting sports nutritionists, which consisted of several processes: administrative, cognitive, interview, training, and skills assessment. Eligible nutritionists had academic qualifications equivalent to Diploma-IV or Strata-I from tertiary institutions with a minimum accreditation of B. Cognitive selection was made via questions related to sports nutrition. Interviews were conducted to determine the communication style and commitment of prospective nutritionists. The trainings aimed to provide the same standards for all prospective nutritionists regarding the management of NCP that will be carried out on athletes, which

**Table 1.** Characteristics of respondents

| *Athlete's characteristic* | *Number of athletes (%)* | | |
|---|---|---|---|
| | *Strength category* | *Endurance category* | *Total* |
| Age (years) | | | |
| 14 | 7 (7.7) | - | 7 (6.1) |
| 15 | 8 (8.8) | 4 (16.7) | 12 (10.5) |
| 16 | 29 (32.2) | 5 (20.8) | 34 (29.8) |
| 17 | 26 (28.8) | 11 (45.8) | 37 (32.5) |
| 18 | 18 (20.0) | 3 (12.5) | 21 (18.4) |
| 19 | 2 (2.5) | 1 (4.2) | 3 (2.7) |
| Total | 90 (100) | 24 (100) | 114 (100) |
| Gender | | | |
| Boy | 42 (46.7) | 13 (54.1) | 55 (48.2) |
| Girl | 48 (53.3) | 11 (45.9) | 59 (51.8) |
| Total | 90 (100) | 24 (100) | 114 (100) |
| Duration of playing sport (years) (*Mean*±*SD* = 6.0±2.5 years) | | | |
| <3 | 5 (5.6) | 1 (4.2) | 6 (5.3) |
| <5 | 23 (25.6) | 2 (8.4) | 25 (21.9) |
| <10 | 53 (58.9) | 17 (70.7) | 69 (60.5) |
| >10 | 10 (9.9) | 4 (16.7) | 14 (12.3) |
| Total | 90 (100) | 24 (100) | 114 (100) |
| Smoker | | | |
| Yes | 3 (3.3) | - | 3 (2.7) |
| No | 87 (96.7) | 24 (100) | 111 (97.3) |
| Total | 90 (100) | 24 (100) | 114 (100) |
| Injury history | | | |
| Yes | 45 (50) | 22 (91.7) | 67 (58.7) |
| No | 45 (50) | 2 (8.3) | 47 (41.3) |
| Total | 90 (100) | 24 (100) | 114 (100) |

ended with a skills assessment to ascertain the skill levels of nutritionists.

Shortly after the placement of sport nutritionists, baseline measurements were taken at each site for performance and nutritional status. Following baseline measurements, the intervention began with the sport nutritionists designing a NCP for each athlete that lasted for three months. During the intervention, anthropometry, somatotype, body composition, and dietary intake were measured once. Finally, post-intervention measurements were taken for all variables that were measured at the beginning of the study.

**Statistics**

Statistical analysis was performed using IBM SPSS Statistics for Windows version 23.0 (IBM Corp, Armonk, New York, USA). Prior to data analysis, a normality test was conducted for each dataset using the Shapiro–Wilk test. A mixed model analysis of variance (ANOVA) was used to compare the mean differences between groups (within and between subjects). Analysis of "Time" was measured to compare before and after intervention (pre – post). Analysis of "Group" was measured to compare between strength and endurance sports categories. "Time X Group" analysis was used to measure the interaction for each variable.

## RESULTS

### Characteristics of respondents

This was a cohort study of 114 Indonesian youth athletes aged 14 to 19 years old, of whom 90 were strength athletes and 24 were endurance athletes. Subjects were followed for two months of intervention based on a NCP for athletes. Informed consent was obtained from all respondents prior to the study. Majority of the subjects were 16-17 years old, with an even split between girls and boys. The sports type was divided into strength and endurance. The strength categories were archery, taekwondo, martial arts, weightlifting, gymnastics, athletic sprinting, and karate. The endurance categories were swimming, football, badminton, climbing, and athletics on medium distance. The strength category contained more girls at 53.3%, while the endurance category involved more boys at 54.1%. The average time for which athletes had been involved in their chosen sport was 6+2.5 years. More than 97% of the athletes do not smoke. Both strength and endurance athletes suffered from injuries (58.7%). All these characteristics can be seen in Table 1.

### Nutrition care process for athletes

All of the athletes in each location were included in the study. Figure 1 shows the data collection flowchart for respondents. Initially, the pre-assessment stage was carried out one month prior to the intervention to conduct initial measurements, prepare nutrition profiles, and practise food portioning among athletes. Monitoring was conducted monthly; the earliest session took place one month after the intervention and comprised education on general nutrition science, nutritional status, food recommendations or food portioning, meal assistance, and training assistance.

### Descriptive data on nutrient intake, body composition, and performance

Following the NCP for two months, it was expected that athletes could adequately fulfil their energy and nutritional needs. As shown in Table 2, the trend of overeating reduced considerably from 11.5% to merely 2.6%. Meanwhile, adequate intake of energy recorded a slight increase of 2%.

Regarding protein intake, more athletes (33.3%) consumed adequate protein after the NCP, followed by a reduction in the number of athletes with excessive or deficient consumption. Even slightly, there was a 29.8% increase in adequate consumption of fats and a 5% decline in subjects with excessive intake. The majority of athletes had been lacking in carbohydrate intake, which reached more than 70% after the NCP.

### Difference on nutrition education during programme

Table 3 shows the results from the mixed model ANOVA analysis, which was matched by the researchers. The indicators used for matching were body mass index (BMI)-for-age and total physical activity of athletes. The results of nutrition education in Table 3 showed significant differences before and after intervention ($p$=0.023), but no difference between strength and endurance groups ($p$=0.734). Nutrition education consisted of counselling for each athlete and group class. The nutrition knowledge consisted of queries about general nutrition and sports nutrition science.

### Differences on fulfilment of nutrient intake during programme

As shown in Table 3, we compared the nutrient fulfilment data to RDA according to athlete's age and gender. Statistically, none of the intakes showed significant changes (calorie intake $p$=0.509; protein intake $p$=0.261; fat intake $p$=0.301; carbohydrates intake $p$=0.776) before and after intervention. There were also no significant changes for calorie, protein, fat, and carbohydrates ($p$=0.796; $p$=0.983; $p$=0.742; $p$=0.983, respectively) between groups.

**Table 2.** Pre- and post-test of nutrient intake, body composition, and performance

| Variable | *Strength, n (%)* | | *Endurance, n (%)* | | *All respondents, n (%)* | |
|---|---|---|---|---|---|---|
| | *Pre* | *Post* | *Pre* | *Post* | *Pre* | *Post* |
| Energy | | | | | | |
| Deficient | 54 (60) | 61 (67.8) | 14 (58.3) | 15 (62.5) | 68 (59.6) | 76 (66.7) |
| Adequate | 26 (28.8) | 27 (30.0) | 7 (29.2) | 8 (33.3) | 33 (28.9) | 35 (30.7) |
| Over | 10 (11.2) | 2 (2.2) | 3 (12.5) | 1 (4.2) | 13 (11.5) | 3 (2.6) |
| Protein | | | | | | |
| Deficient | 62 (68.9) | 56 (62.2) | 14 (58.3) | 12 (50.0) | 76 (66.7) | 68 (59.6) |
| Adequate | 20 (22.2) | 27 (30.0) | 8 (33.3) | 11 (45.8) | 28 (24.6) | 38 (33.3) |
| Over | 8 (8.9) | 7 (7.8) | 2 (8.4) | 1 (4.2) | 10 (8.7) | 8 (7.1) |
| Fat | | | | | | |
| Deficient | 33 (36.7) | 34 (37.7) | 8 (33.3) | 8 (33.3) | 41 (35.9) | 42 (36.8) |
| Adequate | 23 (25.6) | 32 (35.6) | 6 (30.0) | 2 (8.4) | 29 (25.4) | 34 (29.8) |
| Over | 34 (37.7) | 24 (26.7) | 10 (36.7) | 14 (58.3) | 44 (38.7) | 38 (33.4) |
| Carbohydrates | | | | | | |
| Deficient | 64 (71.1) | 65 (72.2) | 16 (61.6) | 20 (83.2) | 80 (70.3) | 85 (74.6) |
| Adequate | 18 (20.0) | 23 (25.6) | 6 (30.0) | 4 (16.8) | 24 (21.0) | 27 (23.7) |
| Over | 8 (8.9) | 2 (2.2) | 2 (8.4) | - | 10 (8.7) | 2 (1.7) |
| % Body fat† | | | | | | |
| Low | 22 (24.4) | 19 (21.1) | 2 (8.3) | 3 (12.5) | 24 (21.1) | 22 (9.3) |
| Normal | 63 (70.0) | 67 (74.4) | 18 (75.0) | 20 (83.3) | 81 (71.1) | 87 (76.3) |
| Over | 5 (5.6) | 4 (4.4) | 4 (16.7) | 1 (4.2) | 9 (7.9) | 5 (4.4) |
| % Muscle‡ | | | | | | |
| Low | 5 (5.6) | 3 (3.3) | 3 (12.5) | - | 8 (7.0) | 3 (2.6) |
| Normal | 54 (60.0) | 60 (66.7) | 18 (75) | 22 (91.7) | 72 (63.2) | 82 (71.9) |
| High | 31 (34.4) | 27 (30.0) | 3 (12.5) | 2 (8.3) | 34 (29.8) | 29 (25.4) |
| Performance ($VO_2$max)§ | | | | | | |
| Poor | - | - | - | - | - | - |
| Below average | 5 (5.6) | 1 (1.1) | - | - | 5(4.4) | 1 (0.9) |
| Average | 26 (28.9) | 19 (21.1) | 2 (8.3) | 3 (12.5) | 28(24.6) | 22 (19.3) |
| Good | 55 (61.1) | 65 (72.2) | 16 (66.7) | 9 (37.5) | 71(62.3) | 74 (64.9) |
| Excellent | 4 (4.4) | 5 (5.6) | 6 (25.0) | 12 (50.0) | 10(8.8) | 17 (14.9) |

†Percentage of body fat was categorised in consideration of sex [boys 18-38 years old: low (<10), normal (10-20), high (20-25), very high (≥25); girls 18-38 years old: low (<20), normal (20-30), high (30-35), very high (≥35)] (Penggalih *et al.*, 2021)

‡Percentage of muscle was categorised in consideration of sex [boys 18-38 years old: low (33.3), normal (33.3-39.3), high (39.4-44.0), very high (≥44.1); girls 18-38 years old: low (<24.3), normal (24.3-30.3), high (30.4-35.3), very high (≥35.4)] (Penggalih *et al.*, 2021)

§Maximal aerobic capacity was categorised in consideration of sex [boys <29 years old: poor (<24), below average (25-33), average (34-42), good (43-52), excellent (≥53); girls <29 years old: poor (<23), below average (24-30), average (31-37), good 38-48(), excellent (≥49)] (Penggalih *et al.*, 2021)

**Differences in skinfolds and body composition during programme**

From the information supplied in Table 3, there was a significant decrease in all parameters of skinfold and body fat percentage in athletes (body fat $p$=0.004; triceps skinfold $p$=0.003; subscapular skinfold $p$=0.016; suprailiac skinfold $p$<0.001; calf skinfold $p$<0.001) before and after intervention. There was a significant difference between the endurance and strength groups for triceps and calf skinfolds ($p$=0.032; $p$=0.049, respectively).

**Table 3.** Associations between type of sports with performance and nutritional status

| *Variable* | *Group* | *Pre* | *Post* | *p-value* | |
|---|---|---|---|---|---|
| | | *Mean±SD* | *Mean±SD* | | |
| Performance ($VO_2$max) | Strength | 41.5±6.5 | 42.7±6.3 | Time | 0.012* |
| | Endurance | 41.2±7.7 | 43.7±5.7 | Group | 0.867 |
| | Time | 41.5±6.8 | 42.9±6.2 | Time x group | 0.344 |
| Score of nutrition knowledge | Strength | 9.3±4.9 | 10.1±4.0 | Time | 0.023* |
| | Endurance | 8.4±4.7 | 11.7±6.4 | Group | 0.734 |
| | Time | 9.1±4.9 | 10.5±4.7 | Time x group | 0.146 |
| Body fat composition (%) | Strength | 19.3±6.5 | 19.3±6.5 | Time | 0.004* |
| | Endurance | 20.5±5.4 | 18.7±5.2 | Group | 0.860 |
| | Time | 19.6±6.2 | 19.2±6.1 | Time x group | 0.002* |
| Triceps skinfold (mm) | Strength | 12.5±4.4 | 10.5±4.2 | Time | 0.003* |
| | Endurance | 9.8±3.3 | 8.5±3.5 | Group | 0.032* |
| | Time | 11.9±4.2 | 10.0±4.1 | Time x group | 0.503 |
| Subscapular skinfold (mm) | Strength | 11.9±3.6 | 10.9±3.7 | Time | 0.016* |
| | Endurance | 10.9±2.5 | 9.8±2.5 | Group | 0.264 |
| | Time | 11.7±3.3 | 10.6±3.5 | Time x group | 0.999 |
| Suprailiac skinfold (mm) | Strength | 14.2±6.3 | 11.9±5.3 | Time | 0.000* |
| | Endurance | 12.6±6.2 | 9.4±4.3 | Group | 0.206 |
| | Time | 13.8±6.3 | 11.3±5.1 | Time x group | 0.463 |
| Calf skinfold (mm) | Strength | 9.9±3.7 | 8.6±4.3 | Time | 0.001* |
| | Endurance | 7.8±3.5 | 6.4±3.7 | Group | 0.049* |
| | Time | 9.5±3.8 | 8.1±4.2 | Time x group | 0.911 |
| Calorie intake to RDA (%) | Strength | 76.2±26.2 | 73.1±24.3 | Time | 0.509 |
| | Endurance | 77.8±30.8 | 74.3±22.1 | Group | 0.796 |
| | Time | 76.5±27.1 | 73.4±23.6 | Time x group | 0.955 |
| Protein intake to RDA (%) | Strength | 69.1±27.9 | 74.5±29.3 | Time | 0.261 |
| | Endurance | 68.4±23.0 | 75.5±28.2 | Group | 0.983 |
| | Time | 68.9±26.6 | 74.8±28.8 | Time x group | 0.880 |
| Fat intake to RDA (%) | Strength | 99.1±48.1 | 112.9±26.2 | Time | 0.301 |
| | Endurance | 105.6±62.6 | 115.5±57.9 | Group | 0.742 |
| | Time | 100.7±51.5 | 113.5±66.9 | Time x group | 0.863 |
| Carbohydrate intake to RDA (%) | Strength | 68.4±26.2 | 64.5±22.7 | Time | 0.776 |
| | Endurance | 65.6±25.3 | 66.9±20.5 | Group | 0.983 |
| | Time | 67.7±25.8 | 65.05±22.1 | Time x group | 0.562 |

Values are expressed as mean±*SD*

Greenhouse-Geisser $p$-levels are reported with univariate analyses for time, group, and time x group interactions for each variable; *$p$<0.05 was significant.

**Differences on performance during programme**

According to Table 3, the athletes' performances revealed a significant increase in oxygen uptake or $VO_2$ max (*p*=0.012) during the intervention period. There was no significant difference between groups or interactions for each variable (*p*=0.867 and *p*=0.344).

## DISCUSSION

The present study was conducted on young athletes from four training centres across Indonesia to assess how an intensive nutrition care process provided by nutritionists and dietitians affected athletes' diet, body composition, and performance. The nutrition care process was established in 2021 in collaboration with the Ministry of Sports in Indonesia (Penggalih *et al.*, 2021). This study reported that a 3-month nutrition care process reduced athletes' body fat composition. Besides that, it also improved health-related fitness component (body composition, cardiorespiratory fitness, muscle strength, and muscular endurance). In this case, we measured $VO_2$max as it is known as one of the many indicators to predict cardiorespiratory fitness or aerobic performance in athletes (Hoeger *et al.*, 2015; *Buttar et al.*, 2019).

One of the components of the NCP is providing nutrition education via nutritionists and dietitians to all athletes, both in class and in small groups. In the present study, the assessment of athletes' nutrition knowledge resulted in a significantly increased score (13%) among athletes. The results in Table 3 showed a significant difference before and after intervention (*p*=0.023), but there was no difference between strength and endurance groups (*p*=0.734). Similar to our results, four sessions of 30-minute nutrition education weekly were shown to increase sports nutrition knowledge in young, male, Chinese soccer athletes, while no change was observed in dietary intake (Zeng *et al.*, 2020). Research conducted by Zaman *et al.* (2021) showed something similar, whereby nutrition education increased knowledge, attitude, and practice (KAP), but not actual dietary intake. A systematic review showed that although majority of studies reported a significant change in the level of nutrition knowledge, but changes in dietary intake were inconsistent (Boidin *et al.*, 2020).

A study has shown the correlation between nutrition knowledge and dietary intake in adolescent athletes (Noronha *et al.*, 2020). Previously, the implementation of a slightly longer nutrition education programme (six weeks) led to improvements in dietary intake (Borjloo *et al.*, 2021). This means that changing habits requires more effort. A study of Malaysian athletes reported improved dietary intake only after eight weeks. The programme, although carried out over a shorter duration than the present study, provided education sessions more frequently: 1-2 hours per week (Mohd Elias *et al.*, 2018). Thus, the duration and frequency of our programme might have been sufficient to elicit changes in athletes' knowledge level, but not at the behaviour level.

The implementation of NCP did not statistically improve any parameters of the athlete's diet, which was measured as a percentage of RDAs fulfilled for calories, carbohydrates, fat, and protein. However, it is worth noting that despite this, most of the athletes's average dietary fulfilment for all macronutrients, both before and after the intervention, was between 80 and 110% of recommendation, which can be classified as adequate. Furthermore, categorisation of athletes' dietary fulfillments after intervention indicated some improvements in terms of the proportion of athletes with adequate intakes of total calories, protein, fat, and carbohydrates (Table 2).

Through this intervention, the researchers did not make changes to the food budget because this has been regulated by the government. The feeding programme in the athletes' dormitories also could not be adjusted to individual needs based on the respective sports and training period when providing food service for a large group. The modification of eating intervention was carried out by calculating the athlete's meal portion according to individual needs. Each athlete received information regarding an individual meal plan through counselling by a nutritionist. This is also in line with research conducted on athletes in Italy, where athletes received nutrition education related to food and had a positive effect on changes in eating patterns (Terenzio *et al.*, 2021).

While dietary intake remained unchanged, the present study indicated that after three months of intervention, an improvement in subcutaneous fat composition was observed. Although total body composition remained unchanged after the intervention, measurements of skinfold at four sites—triceps, subscapular, suprailiac, and calf were all significantly lower than baseline measurements. Remarkably, after the intervention, the present study also reported improved performance, measured as $VO_2$max, by nearly 2 ml/kg/minute. Several studies previously conducted reported that low body fat was correlated with higher physical performance, particularly cardiovascular and muscle endurance (Lubis *et al.,* 2022; Aikawa *et al.*, 2020; Ferreira *et al.*, 2016). Body fat captures non-metabolically active tissue that does not contribute to the physiological capacity to produce force (Ruiz-Castellano *et al.*, 2021), thus increasing adiposity may interfere with muscular performance and impact slow movement in athletes. On the contrary, a lower composition of body fat may be associated with the delayed onset of fatigue and durable endurance capacity (Ruiz-Castellano *et al.*, 2021).

Body composition of young athletes is also influenced by their growth and maturity status. Understanding the expected changes in body composition that accompany normal growth and maturation is essential. Several studies showed that growth spurts in body composition, especially in athletes, occur at the age of 12 years in girls and 14 - 15 years in boys (Desbrow, 2021; Campa *et al.*, 2019). At this age, the growth of fat-free mass (FFM) reaches its highest peak and fat mass (FM) decreases. However, when this study was conducted, the majority of athletes were 16 – 17 years old, so they had already gone through growth spurts for FM and FFM.

This study also aimed to compare the changes before and after intervention between endurance and strength athletes, as well as changes within the same group. It is interesting to note that strength athletes showed a lesser reduction in their skinfold thickness for upper extremity sites (triceps) compared to endurance athletes (Table 3). Indeed, a previous meta-analysis evaluating the effects of strength and endurance training revealed that endurance training led to a higher decrement in body fat, whereas strength training augmented muscle hypertrophy more effectively (Gorner & Reineke, 2020). Additionally, when comparing the baseline data between groups, strength athletes had relatively lower subcutaneous fat compared to endurance athletes. This may be why athletes in this group had lesser reduction in skinfold thickness. It is also worth mentioning that in spite of the minimal reduction in skinfold thickness, strength athletes still significantly improved their performance at post-intervention measurement. This might be explained by the improvement in nutrition knowledge, which led to improved skinfold thickness. $VO_2$max at the end of the study did not differ between groups.

Boullosa *et al.* (2020) stated that genetic, nutrition, training, psychological, and physiological factors can affect the performance of $VO_2$ max. In this study, the respondents were athletes in the same age range and experienced the same physical activity of more than 1000 METS (unpublished data), meaning that their trainings were quite similar. Researchers screened athletes with a cut-off of physical activity at 1000 METS. This is to equate the characteristics of athletes so that confounding variables during statistical analysis can be suppressed. According to the research, physical activity above 1000 METS is in the moderate to high category (Strasser & Burtscher, 2018). Apart from physical activity, the researchers also conducted matching with BMI-for-age. This indicator was used because athletes were still in their growth phase. Athletes who fell into the abnormal category (underweight and overweight) were not included in the analysis. The aerobic capacity of athletes was measured using two methods (Balke test and Bleep test) for verification. A study by Herdiles *et al.* (2017) stated that these two methods gave the same effect on endurance football players. As such, improvement in $VO_2$ max performance was affected by the nutritional status of athletes in this study.

NCP for athletes is a comprehensive process to assist athletes from a nutritional perspective. A study stated that there are three approaches in which NCP in athletes can affect athletes' performance, namely (1) addressing the determinants of eating behaviours, (2) addressing eating behaviours and dietary intake, and (3) addressing the consequences of dietary intake in relation to health and sports performance (Iwasa-Madge & Sesbreno, 2022). Based on the NCP chart in athletes (Figure 2), this study examined the eating behaviours of athletes during dietary assessment. The results of the assessment were then poured into nutrition interventions, where athletes were given education about nutrition profiles, nutrition and sports, as well as portion size of each meal according to their needs. Not only that, the researchers also conducted meal assistance, where nutritionists accompanied athletes at mealtimes. This was a way to improve eating behaviours in athletes who were still lacking.

The design of the NCP in the present study did not solely focus on providing nutrition education and meal assistance; training assistance was also provided monthly to athletes, which consisted of monitoring their hydration status. A study reported that athletes improved their training consistency, suffered from fewer injuries and illnesses, and demonstrated improved resilience after the athletes and coaches received education from nutritionists (Logue *et al.*, 2021). This could be one of the reasons for improved performance in this study, since athletes were given meals and training assistance by nutritionists, who also coordinated with their coaches.

To our knowledge, the present study is the first to implement a comprehensive NCP, which integrated nutritional assistance during mealtimes and training sessions by employing nutritionists or dietitians in government training centres for three full months. While this study also tried to differentiate its impact between endurance and strength athletes, we were aware of the unmatched number of participants between the two groups that might be unfavourable to statistical analysis. Additionally, it must be noted that our intervention did not include tailoring the same training programme for all types of sports. We let the training programmes run as naturally as possible, as designed by the coaches, so that any changes present in the results would be due to the implementation of NCP. Although the nutritionists or dietitians provided regular nutrition reports and recommendations to the coaches and managers of the training centres, they did not have the authority to modify the training programmes. Therefore, training programmes might serve as an uncontrolled confounder, since athletes from different sports might have different training volumes, affecting their body composition and performance outcomes. Though the type of training programmes varied between training centres, the total physical activity of the athletes was similar, at more than 1000 METS (unpublished data).

## CONCLUSION

In conclusion, three months of NCP significantly improved the knowledge of nutrition, body fat composition, skinfold thickness, and performance of athletes. Despite the good intakes of protein and fat, none of the intakes showed significant changes. Furthermore, knowledge of sports nutrition and exercise science had a positive impact on dormitory meal choices. It is imperative that the NCP programme be carried out continuously with the assistance of nutritionists so that all existing parameters reach their expected optimal results based on the targets of each sport.

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**Authors' contributions**

Mirza HSTP, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; Zaenal MS and Laksono T, prepared the draft of the manuscript and reviewed the manuscript; Edi NS and Ernawaty, led the data collection in the Javanese region; Bayu R, Margono, Dadi S, and Raden I, led the data collection in the Lombok and Sulawesi regions; Kurnia MS, Rahadyana M, Naila AS, Veronika DPP, conducted the study, data analysis and interpretation, assisted in drafting of the manuscript, and reviewed the manuscript.

**Conflict of interest**

The authors declare no conflict of interest.

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