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Effects of Goal-Based Undulating Periodization on Muscular Endurance Development

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Abstract

Training programs that are designed and structured through periodization provide maximum improvement effects. Therefore, the periodization used must be appropriate to the expected goals for improving athletes' physical condition. One such method is undulating periodization, which provides many changes in stimulation and recovery periods that are more conducive to increasing strength. The purpose of this study was to determine the application of the undulating periodization training model based on training objectives for improving muscle endurance. The research method used was an experiment with a one-group pretest-posttest design, and the sample consisted of 10 PPLP athletes with disabilities. The undulating periodization model had a significant impact on improving the athletes' physical abilities, especially in terms of strength. Thus, the application of the undulating periodization training model based on training objectives had an effect on improving muscle endurance.

Keywords: periodization, undulating, muscle endurance.

Introduction

In the context of high-performance sports, the achievement of national elite athletes is profoundly influenced by the coach's capacity to optimize the physiological, technical, and psychological potential of their athletes. Nevertheless, performance limitations among elite athletes frequently originate from coaches' inability to fully develop these capacities, largely due to inadequate knowledge and competencies—particularly in the domain of physical conditioning (Sidik et al., 2019). A recurrent issue observed in the field is the lack of precision in determining appropriate training doses and selecting the specific components of training that correspond with the physiological demands of the sport and the individual needs of the athlete. This challenge becomes even more pronounced in circumstances characterized by uncertain or congested competition calendars. Such limitations in understanding comprehensive and sport-specific physical development at the elite level constitute a significant obstacle to achieving peak performance.

To attain superior athletic performance, the implementation of structured, systematic, and purposefully designed training is indispensable. A well-planned physical conditioning program, tailored to the specific bioenergetic and biomechanical demands of the sport, is essential for enhancing the functional capacities that serve as the foundation of competitive success (Sidik et al., 2019). Within this framework, training periodization plays a pivotal role. Periodization refers to a long-term planning strategy that systematically manipulates key training variables—including intensity, volume, frequency, and recovery duration—to optimize physiological adaptation and ensure the athlete reaches peak performance at predetermined times (Naclerio et al., 2013).

Among the various periodization models, linear and undulating periodization are two of the most widely implemented. Undulating periodization, in particular, is characterized by frequent fluctuations in training intensity and volume on a daily or weekly basis. This model provides a broader range of stimuli and allows more frequent neuromuscular recovery compared to traditional linear approaches (Buford et al., 2007). Such characteristics make it especially suitable for elite athletes who must cope with intensive, unpredictable, and often overlapping competitive schedules. Empirical studies have demonstrated that undulating periodization is highly effective in producing significant gains in muscular strength, which subsequently contributes to improvements in muscular endurance, movement efficiency, speed, agility, and injury resilience (Hartmann et al., 2015; Raiola & D'Isanto, 2016).

Given these considerations, a deeper investigation into the influence of undulating periodization on muscular endurance development among elite athletes is both relevant and necessary. Enhanced scientific understanding of this model will equip coaches with evidence-based strategies for designing adaptive and optimized training programs that align with athletes' physiological profiles, competitive demands, and recovery needs. Ultimately, such advancements are expected to contribute meaningfully to the elevation of athletic performance at the national and international stages.

Methods

This study employed an experimental research method. Experimental research is a methodological approach in which the researcher deliberately attempts to influence a particular variable, and when implemented appropriately, it is considered the most rigorous method for testing assumptions. The defining characteristic of experimental research is the researcher's ability to manipulate the independent variable. This includes determining what will occur to the participants, selecting who will be examined, and establishing the extent and conditions under which the manipulation takes place. In an experimental study, the researcher examines all aspects of one independent variable or multiple independent variables and observes their effects on the dependent variable(s) (Fraenkel, Wallen, & Hyun, 2012).

Research Design

The research design utilized in this study was the One-Group Pretest–Posttest Design. In this design, measurements or observations are conducted on a single group both before and after the treatment is administered. Such a design allows researchers to determine whether changes in the dependent variable occur following the implementation of the intervention (Fraenkel, Wallen, & Hyun, *How to Design and Evaluate Research in Education*, 2012).

The general structure of the One-Group Pretest–Posttest Design can be illustrated in the following table:

Table 1. Research Design: One-Group Pretest–Posttest Design

O_1	X	O_2
Pretest	Treatment	Postest

Description:

- O_1 represents the pretest measurement of muscular endurance.

- X represents the undulating periodization treatment.
- O_2 represents the posttest measurement of muscular endurance.

Participants

The study was conducted in the Sport Arcamanik complex in Bandung from March to June 2025. Training sessions were held three times per week, with frequency and training objectives determined based on established principles and norms of training load to ensure that the targeted outcomes were achieved. The participants involved in this study were athletes from the West Java PPLP Disability Program.

Population and Sample

To obtain the necessary data, the study required a clearly defined population. The population refers to the larger group to which the results of the study are intended to be generalized (Fraenkel, Wallen, & Hyun, *How to Design and Evaluate Research in Education*, 2012). It includes individuals who possess the characteristics of interest to the researcher and from whom the researcher seeks to draw conclusions. The population in this study consisted of 28 athletes from the 2025 West Java PPLP Disability Program.

A sample is a subset of the population that possesses the characteristics required for the study. Sampling refers to the process of selecting individuals, groups, or objects from which data will be collected (Fraenkel, Wallen, & Hyun, 2012). The sampling technique used in this study was purposive sampling, based on specific criteria: (1) male athletes and (2) individuals with complete and functional limbs. Based on these criteria, 10 athletes were selected from the population to form the study sample.

Instrument

Research instruments are measurement tools used to collect the necessary data. The instruments employed in this study were as follows:

- Upper-body muscular endurance was assessed using the Cadence Push-Up Test and the Wall Squat Test (Mackenzie, 2005).
- The treatment consisted of an undulating periodization training program, structured according to the intended training goals, including hypertrophy, muscular endurance, and power development.

Data Analysis

The data analysis technique used to evaluate the effects of undulating periodization on muscular endurance components was the Paired Sample t-test. This analysis aimed to determine whether the application of undulating periodization produced significant improvements in upper-body and lower-body muscular endurance. Data processing was conducted using SPSS Version 2.6. Hypothesis testing in this study served as the analytical stage to statistically examine whether the research questions could be answered based on the collected data and computed statistical values.

Results

To draw meaningful conclusions from the study, the data that had been collected were subsequently processed to provide interpretable scores. Data processing in research is essential for determining the answers to the research questions formulated earlier. In this study, data analysis was carried out using the Statistical Product and Service Solutions (SPSS) software, Version 26.

The following section presents the descriptive data obtained from the pretest and posttest measurements of muscular endurance for both the upper and lower body. Descriptive data for upper-body muscular endurance were derived from the push-up test, whereas lower-body muscular endurance data were obtained through the wall squat test, as shown in Table 1.

Based on the descriptive results, it is evident that both upper-body and lower-body muscular endurance improved after the implementation of the undulating periodization training program based on specific training goals. These findings suggest that the undulating training program contributed to measurable improvements in muscular endurance.

Results of the Paired Sample t-Test

The paired sample t-test was conducted to determine whether there was a significant effect or improvement in muscular endurance for both the upper and lower body following the intervention. Data processing was performed using SPSS, and the analysis compared the pretest and posttest scores for upper-body and lower-body muscular endurance. The SPSS output is summarized in Table 1.

Table 1

Descriptive Statistics of Upper and Lower Body Muscular Endurance Tests

Variable	**Pre-test *M***	**Pre-test *SD***	**Post-test *M***	**Post-test *SD***	***t*(9)**	***p***
Push Up (repetitions)	5.70	1.89	12.50	2.84	−15.84	< .001
Wall Squat (seconds)	47.70	9.15	78.50	12.05	−14.92	< .001

From Table 1, the significance value (Sig.) for lower-body muscular endurance was found to be 0.000. The decision-making criteria for hypothesis testing were as follows:

Hypotheses:

a) H_0: There is no significant improvement in lower-body muscular endurance resulting from the implementation of undulating periodization based on training goals.

b) H_1: There is a significant improvement in lower-body muscular endurance resulting from the implementation of undulating periodization based on training goals.

Decision Criteria:

a) If the significance value (Sig.) > 0.05, then H_0 is accepted.

b) If the significance value (Sig.) < 0.05, then H_0 is rejected.

Because the significance value for lower-body muscular endurance was 0.000 < 0.05, it can be concluded that the undulating training program produced a statistically significant improvement in lower-body muscular endurance.

Similarly, the significance value (Sig.) for upper-body muscular endurance was also 0.000. The hypotheses for this component were as follows:

Hypotheses:

a) H_0: There is no significant improvement in upper-body muscular endurance resulting from the implementation of undulating periodization based on training goals.

b) H_1: There is a significant improvement in upper-body muscular endurance resulting from the implementation of undulating periodization based on training goals.

Decision Criteria:

a) If the significance value (Sig.) > 0.05, then H_0 is accepted.

b) If the significance value (Sig.) < 0.05, then H_0 is rejected.

Given that the significance value for upper-body muscular endurance was 0.000 < 0.05, it can be concluded that the undulating periodization training program led to a statistically significant improvement in upper-body muscular endurance.

Discussion

This study was conducted to answer the research questions previously formulated: (1) Does the implementation of undulating periodization based on specific training goals result in a significant improvement in lower-body muscular endurance? (2) Does the implementation of undulating periodization based on specific training goals result in a significant improvement in upper-body muscular endurance?

Based on the results of data processing and statistical analysis, the findings indicate the following:

First, the implementation of undulating periodization based on training goals produced a significant improvement in lower-body muscular endurance. This was evidenced by the higher posttest scores compared to the pretest scores. Second, the implementation of undulating periodization also resulted in a significant improvement in upper-body muscular endurance, as demonstrated by the increased posttest scores relative to the pretest measurements.

These results lead to the conclusion that undulating periodization—structured around hypertrophy, muscular endurance, and power training—provides a positive and measurable impact on improving muscular endurance in both the lower and upper body.

Furthermore, the paired sample t-test results showed significance values lower than the critical t-value for both lower-body and upper-body muscular endurance. This statistical outcome confirms that the undulating training program based on specific training goals contributed significantly to improvements in muscular endurance among West Java PPLP Disability athletes.

These findings support the use of undulating periodization as a recommended training strategy for coaches, especially when preparing athletes for competitions with limited preparation time. This is consistent with the argument of Peixoto et al. (2022), who reported that daily undulating periodization results in greater strength improvements and is an attractive strategy for enhancing body composition, strength, and muscular endurance. Similarly, Franchini et al. (2015) found that a daily undulating periodization (DUP) model produced superior strength improvements compared to a non-periodized single-set program in collegiate female tennis players. Additionally, a study by Lian-Yee Kok et al. (2009) titled *Enhancing Muscular Qualities in Untrained Women: Linear versus Undulating Periodization*, involving 20 untrained women over a 3-week intervention, showed a significant improvement of 41.2%. Their findings reinforce the effectiveness of undulating periodization in enhancing muscular strength, particularly in trained female athletes.

Therefore, to achieve optimal training outcomes aligned with performance targets, coaches must design training programs that correspond to the athletes' needs, conditions, and competitive schedule. Given that elite athletes often face closely spaced competitions, the use of conventional or traditional periodization may not be feasible due to the extensive time required to

develop all fitness components progressively. Consequently, undulating periodization based on training goals serves as a more suitable, effective, and efficient model—especially when time constraints demand rapid yet targeted physical adaptation.

Conclusions

Based on the results of data processing and statistical analysis, the following conclusions can be drawn:

1. The implementation of undulating periodization based on specific training goals produced a significant improvement in upper-body muscular endurance.
2. The implementation of undulating periodization based on specific training goals also produced a significant improvement in lower-body muscular endurance.

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