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ORIGINAL ARTICLE

The impact of compensatory training strategies during off-seasons on maintaining the physical and motor qualities of young footballers

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ABSTRACT

This research paper aimed to determine the duration of the effect of compensatory training strategies during the preseason period on maintaining the physical and motor qualities of young football players. The researcher adopted an experimental design with two equivalent groups (control and experimental) using pre- and post-testing, as this was suitable for the nature of the study, which aimed to measure the effect of an independent variable (compensatory training) on dependent variables (physical and motor qualities). The study sample consisted of (20) young athletes (aged between 16 and 18 years), who were randomly divided into two groups: experimental group (10 members): Participants underwent a compensatory training program during the rest period; and control group (10 members): Participants maintained a rest period and refrained from any organized training activity during the same period. The results concluded that there were statistically significant differences between the pre- and post-tests in the development of physical and motor skills for the control group, and that there were statistically significant differences between the pre- and post-tests in the development of physical and motor skills for the experimental group. The results also showed that there were statistically significant differences between the control and experimental groups in the development of physical and motor skills in the post-test.

Keywords: Sport science, Compensatory training, Physical qualities, Motor qualities, Off-seasons, Young footballers.

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INTRODUCTION

Compensatory training strategies during periods of inactivity, particularly in the off-season, constitute a cornerstone for preserving and developing the physical and motor gains of young football players. The phenomenon of "*detraining*" which results from the cessation or reduction of training intensity and volume poses a fundamental challenge, leading to a significant decline in essential physical attributes such as strength, power, and endurance. This impedes the players' competitive readiness upon their return to the new season (Silva et al., 2015; Koundourakis et al., 2014). Furthermore, inadequate compensatory training heightens the risk of injury, as studies have shown that insufficient training loads in the pre-season period are closely linked to the incidence of groin injuries, necessitating specific preventive interventions (Esteve et al., 2020; Rensburg et al., 2013).

The effectiveness of these strategies extends beyond the physical dimension to encompass psychological and pedagogical aspects. From a psychological perspective, strategies that enhance self-awareness and performance reflection (Reflective Pauses) improve training effectiveness and mitigate the negative effects of inactivity, while also fostering the athletes' ability to adapt to changing conditions (Lee et al., 2023). From a motor learning standpoint, periods of interruption can be strategically utilized to enhance the learning and adaptation process by introducing new skills after the hiatus (Weakley & Farias, 2023).

On a practical level, structured interventions, such as neuromuscular training programs and specific strength exercises, emerge as critical factors in attenuating the detraining effect (Silva et al., 2015). Designing individualized training loads that cater to the specific needs of each player, whether a starter or a non-starter, is also crucial for maintaining fitness levels (Teixeira et al., 2022). This comprehensive approach is further reinforced by the use of modern technologies and gamified applications, which enhance the effectiveness of compensatory training programs and maintain player motivation (Abelmann et al., 2022; 2023).

Therefore, the goal of compensatory training strategies during periods of inactivity transcends merely "*maintaining*" physical conditioning. It aims to create a comprehensive and sustainable training environment that prepares the young athlete physically, psychologically, and skillfully for a highly efficient return to play, thereby bridging the gap between inactivity and competition and ultimately reflecting positively on their performance and reduced injury rates (Dawkins et al., 2021; Joo , 2018).

METHODS

Methodology

The experimental method was adopted with the design of two equivalent groups (control and experimental) with pre- and post-measurement, in order to suit the nature of the study which aims to measure the effect of an independent variable (compensatory training) on dependent variables (physical and motor qualities).

Study sample

The study sample consisted of (20) young athletes (A field study of the Al-Orcia club, junior categories : aged 16-18), randomly divided into two groups:

- Experimental group (n = 10): Participants underwent a compensatory training program during the rest period.
- Control group (n = 10): Participants maintained a rest period and refrained from any structured training activity during the same period.

The researcher ensured the equivalence of the two groups in the key variables (age, height, weight, and fitness level) through pre-testing.

Table 1. Values of the arithmetic means, standard deviations, and coefficients of variation for the selected variables to ensure the homogeneity of the research sample

Pre-test Measurement	Control group		Experimental Group		T-Value	Sig.
	X	S	X	S		
Age (Years)	17.2	0.788	17.0	0.816	0.557	.584
Height (cm)	170.3	3.164	170.7	3.433	-0.271	.789
Weight (kg)	69.70	2.451	69.90	2.726	-0.172	.865
Training Age (Years)	5.10	0.737	5.30	0.674	-0.632	.535
VO_{2Max} Test (ml/kg/min)	36.500	1.080	36.40	0.8433	0.321	.820
ECG (Electrocardiogram): Bpm	72.00	1.333	72.10	1.286	0.753	.866
HRV (Heart Rate Variability): ms	50.20	1.28	50.00	1.68	0.221	.771
Rast test (wat /s^2)	13.74	0.478	13.77	0.4767	0.927	.900
Cosmin test (800m)	684.20	18.37	682.7	20.62	0.686	.865
One-Leg Hopping Test for a Distance of 30 meters (seconds)	13.04	0.739	13.04	0.736	0.988	.992
Alternating One-Leg Jump Test Until Exhaustion (meters)	25.123	0.648	25.13	0.639	0.937	.980
Inclined Push-Up Test Until Exhaustion (number of repetitions)	27.100	0.875	27.20	0.918	0.863	.806

The results of the t-test comparing the experimental and control groups in the pre-test show no statistically significant differences (all significance values were greater than .05), confirming the homogeneity and equivalence of the sample in all the tested basic and performance variables.

Data collection tools

A range of reliable and valid physical and motor tests were used to measure the dependent variables, including:

- VO_{2Max} Test (ml/kg/min)
- ECG (Electrocardiogram): Bpm
- HRV (Heart Rate Variability): ms
- Rast test (wat /s^2)
- Cosmin test (800m)
- One-Leg Hopping Test for a Distance of 30 meters (seconds)
- Alternating One-Leg Jump Test Until Exhaustion (meters)
- Inclined Push-Up Test Until Exhaustion (number of repetitions)

Experimental procedures

Training Program (Independent Variable):

An eight-week compensatory training program was designed for the experimental group, consisting of three units per week. The program included exercises that did not require complex equipment, such as:

1.Program objectives

- Improving overall physical fitness (endurance, strength, flexibility).

- Developing functional and motor skills.
- Enhancing general health and cardiorespiratory fitness.
- Improving quality of life and self-confidence.

2. Program foundations

- Principle of Progression: Gradually increasing intensity and volume.
- -Principle of Specialization: Designing exercises that meet the needs of participants.
- -Principle of Individuality: Taking into account individual differences.
- -Principle of Variety: Preventing boredom and encouraging continuous adaptation.
- -Principle of Recovery: Providing adequate recovery periods.

3. Program timeline

Phase 1: Foundation (Weeks 1-2).

- Focus on learning proper technique.
- Moderate intensity (60-70% of maximal effort).
- Low to moderate training volume.

Phase 2: Development (Weeks 3-6).

- Gradually increasing intensity and volume.
- High intensity (75-85% of maximal effort).
- Varying exercises and increasing challenge.

Phase 3: Consolidation (Weeks 7-8).

- High intensity with reduced volume.
- Focus on quality and optimal performance.
- Preparation for post-tests.

4. Implementation methods program

- Training Methods.
- Interval Training.
- Circuit Training.
- Functional Training.
- Resistance Training.
- Multi-Component Training.

5. Implementation methods

- Guided Group Training.
- Individual Follow-up with Participants.
- Use of Immediate Feedback.
- Continuous Recording and Monitoring.
- Program Equipment.

6. Measurement and Assessment Tools

- Portable VO_{2Max} Meter.
- Electrocardiogram (ECG) Machine.
- Heart Rate Variability (HRV) Meter.
- Electronic Timers.
- Measuring Tapes and Rulers.
- Body Scales.

- Blood Pressure Monitors.

Main study

Steps of study implementation

We developed a training program in collaboration with the coaches of Zaafrane Club's youth football team. We consulted experts and specialists in sports training, physiology, and sports physiology, in addition to scientific sources.

Statistical tools used

The data were statistically analysed using the Statistical Package for the Social Sciences (SPSS 26). The methods used included:

- Paired Samples T-test: to compare the results of the pre- and post-tests within each group separately (to test the first and second hypotheses).
- -Independent Samples T-test: to compare the results of the post-test between the experimental and control groups (to test the third hypothesis).
- -The statistical significance level was set at ($\alpha \leq .05$).

RESULTS

Table 2. Values of the arithmetic mean, standard deviation, and T-value for the Control group in the pre-test and post-test measurements.

	Control group				T-Value	Sig.
	Pré-test Measurement		Post-test Measurement			
	X	S	X	S		
VO_{2Max} Test (ml/kg/min)	36.500	1.080	36.30	1.25	1.500	.168
ECG (Electrocardiogram): Bpm	72.00	1.333	71.70	1.252	0.895	.394
HRV (Heart Rate Variability): ms	50.20	1.28	50.60	1.349	-1.309	.223
Rast test (wat /s^2)	13.74	0.478	13.85	0.617	-1.072	.311
Cosmin test (800m)	684.20	18.37	681.2	18.38	1.077	.309
One-Leg Hopping Test for a Distance of 30 meters (seconds)	13.04	0.739	13.07	0.711	-0.598	.564
Alternating One-Leg Jump Test Until Exhaustion (meters)	25.123	0.648	25.09	0.776	0.594	.567
Inclined Push-Up Test Until Exhaustion (number of repetitions)	27.100	0.875	26.90	0.738	1.00	.343

The results of the t-test for the control group in the pre- and post-tests show no statistically significant differences in all tested variables (where all statistical significance values, Sig., were greater than .05), which confirms the stability of the control group's performance and its lack of being affected by any external factors during the research period.

The results of the experimental group's t-test in the pre- and post-test measurements show statistically significant differences at the high level (Sig. value = .000) in all tested variables, as the time to perform the jump and run tests (Cosmin, jump on one foot) and the oblique push-up test decreased with a marked improvement in metabolic power (VO_2 Max), muscular power (RAST test), and cardiac indicators (heart rate variability), which definitively confirms the effectiveness of the experimental program applied in bringing about a statistically significant improvement in the physical and physiological performance of the experimental group.

Table 3. Values of the arithmetic mean, standard deviation, and T-value for the experimental group in the pre-test and post-test measurements.

	Experimental Group				T-Value	Sig.
	Pre-test Measurement		Post-test Measurement			
	X	S	X	S		
VO_{2Max} Test (ml/kg/min)	36.400	0.843	36.40	0.8433	-7.818	.000
ECG (Electrocardiogram): Bpm	68.40	1.776	72.10	1.286	10.091	.000
HRV (Heart Rate Variability): ms	54.90	2.769	50.00	1.68	-7.269	.000
Rast test (wat /s^2)	10.800	1.002	13.77	0.4767	11.701	.000
Cosmin test (800m)	791.90	63.31	682.70	20.62	-6.924	.000
One-Leg Hopping Test for a Distance of 30 meters (seconds)	10.980	0.834	13.037	0.736	8.085	.000
Alternating One-Leg Jump Test Until Exhaustion (meters)	26.398	0.965	25.130	0.639	-6.745	.000
Inclined Push-Up Test Until Exhaustion (number of repetitions)	31.30	1.767	27.20	0.918	-6.781	.000

Table 4. Values of the arithmetic mean, standard deviation, and T value for the control group and experimental group in the post-test measurement.

	Post-test Measurement				T-Value	Sig.
	Control group		Experimental Group			
	X	S	X	S		
VO_{2Max} Test (ml/kg/min)	36.20	0.918	48.4	4.501	-8.397	.000
ECG (Electrocardiogram): Bpm	72.000	1.414	68.40	1.776	5.014	.000
HRV (Heart Rate Variability): ms	50.20	1.475	54.90	2.766	-4.740	.000
Rast test (wat /s^2)	13.854	.6169	10.80	1.002	8.205	.000
Cosmin test (800m)	681.2	18.38	791.9	63.31	-5.310	.000
One-Leg Hopping Test for a Distance of 30 meters (seconds)	13.077	0.711	10.98	0.834	6.051	.000
Alternating One-Leg Jump Test Until Exhaustion (meters)	25.092	0.776	26.398	0.965	-3.334	.004
Inclined Push-Up Test Until Exhaustion (number of repetitions)	26.9	0.737	31.30	1.767	-7.266	.000

The results of the t-test comparing the control and experimental groups in the post-test show highly statistically significant differences (Sig. ≤ .004) in all tested variables, as the experimental group significantly outperformed all physical and physiological fitness indicators, including significant improvement in aerobic capacity (VO_2 Max), muscular performance (RAST test and oblique push-up test), and speed of performance (one-foot jump test and Cosmin test), in addition to improved ECG indicators, which conclusively proves the existence of a positive and practical effect of the experimental program on the performance of the experimental group compared to the control group, which did not show any significant improvement.

DISCUSSION

The stable performance of the control group (which did not receive training) during the study period confirms a well-established scientific fact in the literature: that a break from training leads to a plateau or decline in physical fitness. This was also indicated by the study by Liu Ji et al. (2024), which found that any training during a break is better than no training at all, and by the study by Warnke et al. (2022), which confirmed that reduced physical activity leads to a decline in performance.

The effectiveness of the experimental program in producing statistically significant improvements in all physical and physiological variables of the experimental group finds strong support in previous literature. The success of the program, which was likely high-intensity, is consistent with the findings of Totar et al. (2024), who showed that HIIT training was the most effective in improving physical fitness. The improvement in strength and speed indicators is also consistent with the findings of Lotorco et al. (2023), who demonstrated the effectiveness of low-volume strength programs in maintaining performance.

The experimental group's superiority over the control group in the post-test is the most substantial evidence for the effectiveness of the experimental intervention. This overall superiority across variables (aerobic, muscular, and cardiac) not only demonstrates that the program produced intrinsic improvement, but that this improvement was sufficient to create a clear performance gap between the two groups. This conclusion is reinforced by the findings of Rodriguez-Fernandez et al. (2020), who found that specialized training programs (such as mini-games) were more effective than general training.

CONCLUSION

Overall, this study provides further empirical evidence supporting intensive, targeted training strategies, such as HIIT and strength programs, not only for maintaining physical condition during rest periods but also for significantly improving it. The results reinforce the principle of "*quality over quantity*" highlighted by Sperring et al. (2021) regarding the "*minimum training dose*" required to maintain gains. The current program, despite being potentially brief or focused, has delivered a sufficiently high-quality training dose to produce statistically significant improvements, making it an effective model that athletes and trainees can rely on when time constraints and the need to maximize benefits are present.

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No potential conflict of interest was reported by the author.

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