Performance in modern pentathlon: analyzing the interdependence of events in men and women

Rendimiento en pentatlón moderno: analizando la interdependencia de las pruebas en hombres y mujeres

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How to cite in APA

Alexandria, D., Cerda Kohler, H., Cunha de Mello Pedreiro, R., Augusto Dalmonte Malacarne, J., A Mauricio, C., Nascimento, L., Ferreira Gonçalves, A., José Brito, C., Ignácio Valenzuela Pérez, D., & Miarka, B. (2025). Performance in modern pentathlon: analyzing the interdependence of events in men and women. *Retos*, *66*, 565–572. https://doi.org/10.47197/retos.v66.111186

Abstract

Introduction: Modern Pentathlon is an Olympic discipline involving fencing, swimming, riding, laser-run, where performance in one discipline can significantly impact performance in others.
Objective: This study investigated the interdependence of Modern Pentathlon disciplines and how these disciplines mutually influence each other.
Methodology: This study adopts a cross-sectional, observational-documentary research design, possessing descriptive and correlational characteristics. A sample of 14 athletes, including 5 women (mean age 21 ± 5.22 years, body mass 56.30 ± 1.90 kg, and mean training time 6.20 ± 4.09 years) and 9 men (mean age 22.11 ± 6.13 years, body mass 70.0 ± 6.13 kg, and mean training time 6.89 ± 3.48 years). All athletes were members of the Brazilian Modern Pentathlon team, aged between 14 and 33 years. Data collection occurred during the 2021 Rio Modern Pentathlon Cup, which featured swimming, fencing, and laser-run events but excluded equestrian.
Results: The results reveal correlations between swimming time and laser-run time (r= 0.730**), swimming time and fencing touch victories (r= -0.681**), laser-run time and fencing touch victories (r= -0.535*), and training time and fencing touch victories (r= 0.549*). Conclusions: The interdependence of disciplines in Modern Pentathlon proves crucial for understanding how these modalities intertwine. Such interaction provides valuable insights, enabling the development of more sophisticated training strategies, ultimately enhancing performance in competitions.

Keywords

Interdependence of disciplines, performance analysis, rules, sports training, tactics.

Resumen

Introducción: El pentatlón moderno es una disciplina olímpica que incluye esgrima, natación, equitación, carrera.y tiro con pistola con láser, donde el desempeño en una prueba puede influenciar en las demás.
Objetivo: Analizar la interdependencia entre las disciplinas del pentatlón moderno y cómo se afectan mutuamente.
Metodología: Estudio transversal, observacional y documental, con enfoque descriptivo y correlacional. La muestra incluyó 14 atletas del equipo brasileño (5 mujeres, edad media 21 ± 5,22 años, 56,30 ± 1,90 kg, 6,20 ± 4,09 años de entrenamiento; y 9 hombres, edad media 22,11 ± 6,13 años, 70,0 ± 6,13 kg, 6,89 ± 3,48 años de entrenamien-to), entre 14 y 33 años. Los datos se recogieron durante la Copa de Pentatlón Moderno de Río de Janeiro del 2021, que incluyó natación, esgrima,carrera y tiro con pistola láser, excluyendo equitación.
Resultados: Se encontraron correlaciones significativas entre el tiempo de natación y el de carrera láser (r= 0,730**), el tiempo de natación y las victorias de toque en esgrima (r= -0,681**), el tiempo de carrera láser y las victorias de toque en esgrima (r= -0,535*), y el tiempo de entrenamiento y las victorias de toque en esgrima (r= 0,549*).
Conclusiones: La interdependencia entre disciplinas es clave para entender su interacción y diseñar entrenamientos más eficaces que optimicen el rendimiento en las competencias(usar torneos tb pode ser). Interdependencia de disciplinas, análisis del rendimiento, reglas, entrenamiento deportivo, táticas.

Palabras Clave:

Análisis del rendimiento, entrenamiento deportivo, Interdependencia de las disciplinas, reglas, tácticas.

Introduction

Modern Pentathlon, an Olympic sport comprising five disciplines - fencing, swimming, equestrian, and the combined event of running and shooting - has its roots deeply embedded in the history of the modern Olympics (Demarie, Chirico, & Billat, 2022). Institutionalized by the visionary Baron de Coubertin, the founder of the Modern Olympic Games, Modern Pentathlon was officially inaugurated at the Stockholm Olympics in 1912 (Lee, Lee, & Oh, 2013). Despite its historical significance, the introduction of female athletes occurred much later, with their inclusion at the Sydney Olympics in 2000, marking a pivotal moment for gender representation in the sport (Union Internationale de Pentathlon Moderne [UIPM], 2020; Confederação Brasileira de Pentatlo Moderno, 2021). The inherent interconnection between the disciplines presents itself as a determinant variable in training design, emphasizing the need for personalized regimens that address individual athlete capabilities, motivation, effective fatigue management, recovery protocols, and injury prevention strategies (Leunda-Goni 2024; Sedeaud et al., 2020; Revelles 2017).

In the study by Demarie, Chirico, and Billat (2022), the differential impact of each discipline on the overall points calculation is explored. Findings indicate a varying influence, with fencing contributing 15%, swimming and equestrian each accounting for 20%, and the laser-run event representing 45% of the scoring weight, emphasizing its perceived critical importance. However, such findings are not unanimous. When evaluating factors related to physical fitness and performance in Modern Pentathlon, it was discerned that in Korean national-level competitions, fencing, swimming, and equestrian are more impactful for overall scoring compared to laser-run. Conversely, at international-level competitions, the combined event demonstrated greater relevance (Ko, Cho, Chae, & Lee, 2021).

The Modern Pentathlon takes place in a single day, adopting a cumulative scoring system (Le Meur, Hausswirth, Abbiss, Baup, & Dorel, 2010). Each pentathlete faces multifaceted challenges, from fencing, through swimming (200 meters), to a horse-jumping circuit, ranging from 350 to 450 meters, performed on a horse drawn by lot just twenty minutes before the start (Qiao et al., 2022). Performances in the initial events determine the starting sequence for the combined event, known as the Handicap, where shooting and running intertwine (Le Meur et al., 2010).

The Laser-run event demands the athlete to cover about thirty meters to a shooting station, where there is a fifty-second limit to hit five targets positioned ten meters away (Chirico et al., 2019). Subsequently, the athlete engages in an eight-hundred-meter run, repeating this cycle four times (Chirico et al., 2019). The champion is determined by the accumulation of points throughout the events (UIPM, 2020). As previously alluded to, the laser-run's significant weight in scoring highlights its critical importance in defining the overall champion, although this emphasis is debated among experts (Demarie et al., 2022). Other researchers underscore the synergy between two contrasting skills: one of high energy and cardiovascular demand, and the other of meticulous precision (Demarie et al., 2022). This suggests that deeper investigations are required to elucidate the balance between physical and technical factors influencing performance.

The points allocation system in Modern Pentathlon is meticulously distributed among the disciplines (Demarie et al., 2022). In fencing, points are scored based on the number of bouts and participants, with a pentathlete earning 250 points by winning 70% of the bouts (UIPM, 2020). Performances that exceed or do not reach this percentage result in the addition or subtraction of points, proportionally to the number of bouts contested (UIPM, 2020). In swimming, the two-hundred-meter race is classified based on time, where a standard performance of 2:30.00 results in 250 points. For every third of a second above or below that time, points are added or subtracted (UIPM, 2020). In equestrian, pentathletes start with 300 points, but faults, refusals, or falls result in penalties (UIPM, 2020). For the Laser-run, the initial score is determined by the sum of the previous disciplines, determining the athletes' starting interval (Le Meur et al., 2010). The conclusion of the event determines the final score, consolidating the position in the overall ranking (UIPM, 2020).

Thus, the peculiarities of Modern Pentathlon challenge both athletes and coaches, requiring a combination of physical, technical, and mental skills. Recent studies underline the need for an integrated approach in training and competition preparation, focusing on the interdependence between disciplines and developing strategies that harmonize technical precision with physical endurance to maximize performance (Demarie et al., 2022; Sedeaud et al., 2020). Continuous research and performance analysis in

Modern Pentathlon will provide additional insights into the ideal preparation, competitive strategies, and physiological adaptations necessary to achieve excellence in this unique and historically rich discipline.

Method

This study adopts a cross-sectional, observational-documentary research design, possessing descriptive and correlational characteristics. The cross-sectional design provides a snapshot of relationships between performance metrics and specific events in Modern Pentathlon, focusing on high-level athletes.

Participants

Data were extracted from publicly available sources (https://pentatlo.org.br/) for a sample of 14 athletes, including 5 women (mean age 21 ± 5.22 years, body mass 56.30 ± 1.90 kg, and mean training time 6.20 ± 4.09 years) and 9 men (mean age 22.11 ± 6.13 years, body mass 70.0 ± 6.13 kg, and mean training time 6.89 ± 3.48 years). All athletes were members of the Brazilian Modern Pentathlon team, aged between 14 and 33 years. They were ranked and had participated in local, regional, and national competitions within the six months preceding the study. Data collection occurred during the 2021 Rio Modern Pentathlon Cup, which featured swimming, fencing, and laser-run events but excluded equestrian. Consequently, the competition was classified as a tetrathlon. All data used were publicly accessible, making them secondary in nature. During analysis, no identifying details about the athletes were disclosed to ensure anonymity.

It is important to note that there was no interaction or direct contact between the researchers and the athletes. As per Article 1, paragraph one, item III of Resolution CNS No. 510, dated April 7, 2016, this study did not require approval by the Research Ethics Committee (REC) or the National Research Ethics Committee (CONEP), as the data analyzed were publicly available.

Procedure

Performance data were extracted from the official website of the Brazilian Modern Pentathlon Confederation. The competition analyzed included three events: swimming, fencing, and laser-run, held as part of the Copa Rio 2021. Equestrian events were not conducted, which is why the competition was referred to as a tetrathlon. The swimming event consisted of a 200-meter freestyle race held in a 50-meter pool, with results recorded by official timekeeping referees. In fencing, all athletes competed against each other, with matches structured according to gender-specific formats. As per the UIPM Competition Rules, double touches were not counted, leading to either one winner or two losers per bout.

The laser-run event took place on an 800-meter circuit featuring varied terrain. Athletes' starting order in the laser-run was determined by a handicap system based on their prior performance, and final times were adjusted accordingly to calculate overall rankings.

Data analysis

The collected data were subjected to the Shapiro-Wilk test, as this method is more appropriate for small sample sizes. Levene's test was used to assess homogeneity of variances. Results were reported as mean and standard deviation (SD). Differences between male and female athletes were analyzed using Student's t-test, and Pearson's correlation coefficient was applied to evaluate relationships between performance variables. A significance level of $p < 0.05$ was adopted for all analyses. All statistical analyses were conducted using IBM SPSS Statistics for Windows (Version 20.0).

Results

The Table 1 presents descriptive data related to each of the events contested on competition day.

Table 1. Descriptive data related to each of the events contested on competition day

	Mean		Woman		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI	
Variables	Mean	Std. Deviation	Mean	Std. Deviation						Lower	Upper
Swimming Time (s)	137.96	11.35	147.66	7.01	-1.975	11.715	0.072	-9.700	4.912	-20.43	1.032
Fencing Touch Victories	14.33	2.78	13.40	1.14	0.881	11.469	0.396	0.933	1.059	-1.39	3.25
Defeat in Fencing Touches	7.67	2.78	6.60	1.14	1.007	11.469	0.335	1.067	1.059	-1.25	3.39
Time of laser-run (s)	756.22	80.13	852.00	51.90	-2.707	11.513	0.020	-95.778	35.385	-173.23	-18.3

When analyzing the results by gender, no significant differences were detected in fencing victories and defeats between men (14.33 ± 2.78) and women (13.40 ± 1.14) touches. However, the analysis of laser-run results found a significant difference between genders, with men (756.22 ± 80.13) seconds and women (852 ± 51.90) seconds, indicating that men are faster in this discipline. Although men perform better in some disciplines, in precision activities such as archery, there do not seem to be significant differences between genders (Destriani, 2024). This data can be explained physiologically by the observation that men have a larger heart and, therefore, greater cardiorespiratory capacity and they exhibit greater sympathetic activation compared to women. (Harms, 2006; Rochel et al., 2024). Additionally, other physiological and biological differences between male and female sexes may influence performance in aerobic activities, such as hormonal disparities, with men generally having higher levels of testosterone and women having higher levels of estrogen, which can affect body composition (Harms, 2006).

The Table 2 presents the correlation between events, gender, and training time in Modern Pentathlon.

Table 2. Correlation between events, gender, and training time in Modern Pentathlon

Analysis Variables	Sex	Training Time	Swimming Time (s)	Fencing Touch Victories	Defeat in Fencing Touches	Time of laser-run (s)
Sex	1	-.096 .744	.445 .111	-.200 .493	-.227 .435	.567* .034
Training Time	-.096 .744 .000	1 .555	-.399 .157 .971	.549* .042 .480	-.504 .066 .038	-.340 .234 .619
Swimming Time (s)	.445 .111	-.399 .157	1	-.681** .007	.487 .077	.730** .003
Fencing Touch Victories	-.200 .493	.549* .042	-.681** .007	1	-.909** .000	-.535* .049
Defeat in Fencing Touches	-.227 .435	-.504 .066	.487 .077	-.909** .000	1	.290 .314
Time of laser-run(s)	.567* .034	-.340 .234	.730** .003	-.535* .049	.290 .314	1

Note: In gender – the higher the correlation, the more associated with women; the lower the correlation, the more associated with men; ** significant correlation < 0.01 and * significant correlation < 0.05.

The results show a correlation between swimming time and laser-run time (r= 0.730**), swimming time and fencing touch victories (r= -0.681**), laser-run time and fencing touch victories (r= -0.535*), and training time and fencing touch victories (r= 0.549*).

Discussion

The primary aim of this investigation was to assess the correlation between performance in the events comprising Modern Pentathlon—excluding equestrian—and the subsequent impact on athletes' overall performance. Additionally, an effort was made to identify potential disparities in results between male and female competitors.

Upon analyzing the data, a moderate positive correlation was observed between training time and fencing touch victories. This suggests that fencing experience may be a crucial factor for satisfactory performance, as with experience, technical and tactical combat actions tend to improve. This finding aligns with previous research by Porath et al. (2012), who analyzed the technical-tactical performance of young volleyball players and observed that more experienced athletes demonstrated superior decision-making and execution skills. Similarly, Alves et al. (2015) reported that experienced muay-thai practitioners, particularly those in the black belt category, exhibited faster reaction times. These parallels highlight the cross-disciplinary relevance of accumulated experience in performance contexts.

Furthermore, a moderate negative correlation was identified between the number of fencing combat victories and the time spent in the swimming event. This result suggests a potential synergy between these events, where success in one discipline might positively influence another. Such interrelations emphasize the well-roundedness required for pentathletes. Ko et al. (2021) similarly identified significant correlations between combined event performances and overall results at both national and international levels, further corroborating this study's findings.

The energetic demands of the events also merit attention. The 200-meter swimming event primarily relies on glycolytic energy pathways (Demarie et al., 2010). Stellingwerff et al. (2019) emphasized that middle-distance races, like swimming, depend on an efficient anaerobic energy system, often resulting in lactate peaks exceeding 20 mmol/L. Similarly, Dadswell et al. (2016) examined pentathletes' blood lactate levels and highlighted the critical role of anaerobic metabolism in the Laser-run event. These findings underscore the metabolic diversity Modern Pentathlon demands, requiring athletes to transition efficiently between events with varying energy system requirements.

The findings of this research reiterate the intricate relationship between the events of Modern Pentathlon. This complexity underscores the necessity of a holistic approach in athlete training and preparation that integrates physical, metabolic, and tactical dimensions. By understanding these correlations more comprehensively, coaches and athletes can develop more effective training strategies tailored to the multifaceted nature of this Olympic sport.

However, it is important to consider a limitation of this study: the relatively small sample size. This limitation restricts the generalizability of the findings, emphasizing the need for future research incorporating larger samples to validate and extend these results. Additionally, future studies should integrate a broader range of variables—both physiological and psychological—to provide a more comprehensive understanding of performance determinants in Modern Pentathlon. This could help identify long-term patterns and correlations, offering further insights into performance optimization.

In summary, this research aimed to explore the interrelations within Modern Pentathlon. The results indicate that training time and accumulated experience are key determinants of athletes' success. These findings provide valuable insights for improving sports training strategies and emphasize the importance of a multidimensional approach to preparation, considering the unique challenges of this demanding Olympic discipline.

Conclusions

The interdependence of disciplines in Modern Pentathlon—fencing, swimming, equestrian, and laser-run—is crucial for understanding how these modalities intertwine. This intricate interaction underscores the importance of developing comprehensive training strategies tailored to the demands of each discipline, ultimately enhancing performance in competitions**.** The findings of this study offer significant contributions, not only in practical application but also in theoretical understanding, serving as a foundation for future research. As investigations delve deeper into the interrelations among Modern Pentathlon disciplines, integrating crucial technical and tactical insights into training plans will be essential for optimizing athlete performance.

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