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Analysis of Energy Systems in Greco-Roman and Freestyle Wrestlers Who Participated in the 2015 and 2016 World Championships

Bahman Mirzaei,¹ Mahdi Ghahremani Moghaddam,² and Heydar Alizae Yousef Abadi³

ABSTRACT. The aim of this study was to analyze the energy systems in all Greco-Roman (GR) and freestyle (FS) wrestlers who participated in the 2015 and 2016 world championships (WCh). The materials of the present study consisted of 801 videos (679 of 2015 WCh; 122 of 2016 WCh) that were posted by United World Wrestling (UWW) on their website, along with a multimedia player (laptop) for watching the videos and a chronometer to record the duration of wrestling matches. Data were recorded on specially designed sheets that were prepared in advance. The relative contribution of energy systems in a wrestling match is presented. Moreover, there were some differences between wrestling styles and WCh in respect to relative contribution of energy systems. We determined the quality and quantity of obtained scores by both GR and FS wrestlers. Results showed that FS wrestlers generally score more points than GR wrestlers. Additionally, we investigated the placers' competition efficiency, which showed that top wrestlers who won the gold medals also had a better competition efficiency than other placers, and this difference was statistically significant ($p < 0.05$).

Keywords: energy systems, obtained scores, competition efficiency, world championships

INTRODUCTION

Since the beginning of time, wrestling has been one of the major physical activity of humankind (Mirzaei, Curby, Rahmani-Nia, & Moghadasi, 2009). Moreover, it was one of the few original events in the ancient Olympics (Horswill, 1992). Today, wrestlers compete in Greco-Roman (GR) or freestyle (FS) wrestling all over the world. In GR wrestling, grasping the opponent's lower body is forbidden, as are leg attacks or using the legs actively to perform any actions. On the other hand, in FS wrestling these actions are permitted. These differences in the rules

allow GR and FS to be viewed as different combat sports (Chino, Saito, Matsumoto, Ikeda, & Yanagawa, 2015).

World champions demonstrate the best quality of wrestling, and it is important for coaches to analyze the technical and tactical structure and the efficiency of winners to compare their athletes with other top athletes (Tünnemann, 2013; Tünnemann & Curby, 2016). Furthermore, understanding the physical and physiological factors that contribute to successful wrestling is one of the challenges coaches and wrestlers confront (Mirzaei et al., 2009). Of note, periodic changes in wrestling rules by United World Wrestling (UWW), which usually happen after each Olympic Games, also influence the methods of training used by successful wrestlers and their coaches (Horswill, 1992). Because of these changes, the profile of wrestlers in previous studies may not be relevant today (Mirzaei et al., 2009). For instance, a number of wrestling regulations were modified after the 2012 and 2016 Olympic Games. Particularly, the structure of a match is now two 3-minute periods rather than three 2-minute periods, and judging criteria have been modified as well. These changes have altered the physiological challenges to the various energy-delivery systems (Mirzaei et al., 2009) and wrestlers must choose an attack-oriented

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strategy and be more aggressive in matches, as there are penalties for defensive ones (Ohya et al., 2015).

A wrestling match is an alternative physical activity of variable intensity. It is characterized by sudden, explosive attacks and counterattacks that are repeatedly executed. In wrestling, as in many other sports, energy systems (anaerobic and aerobic) are employed to various degrees (Karnincic, Tocilj, Uljevic, & Erceg, 2009). The anaerobic system provides quick bursts of maximal power during the match, whereas the aerobic system contributes to the wrestler's ability to maintain effort for the duration of the match and to recover between periods (Ohya et al., 2015). The anaerobic system is further subdivided into the ATP-PC energy system (for an immediate, explosive energy source) and the Lactic acid energy system (for intense efforts of a longer duration). The interaction and relative contributions of these three energy systems during periods of maximal exhaustive exercise (like a wrestling match) have been of considerable theoretical and practical interest since 1960s and 1970s (Gastin, 2001).

However, the dynamic nature and unpredictable situations in which wrestlers are engaged, along with the energy demands of the situations, such as offense and defense positions, make designing a wrestling program hard for trainers and coaches. For this reason, estimating the energy demands in elite wrestlers can help wrestlers and their coaches plan well-designed programs.

As Gastin (2001) mentioned, the relative contribution of three energy systems depends on the intensity and duration of exercise. Because of this, we thought it would be possible to estimate the relative contribution of the three energy systems by recording the duration of activities of wrestling matches using World Championship (WCh) recorded videos. Therefore, the purpose of this study was to analyze the energy systems in GR and FS wrestlers who participated in the 2015 and 2016 World Championships.

METHODS

The research materials included all videos of the 2015 and 2016 WCh (non-Olympic weight classes; 61 and 70 kg in FS, 71 and 80 kg in GR), which were posted by the UWW on their website; a multimedia player to watch and analyze the videos; and a chronometer to measure the different activities of matches. The material consisted 801 videos (679 videos of the 2015 WCh and 122 videos of the 2016 WCh) in different weight classes of GR and FS wrestling. According to the objectives of this study, each video was analyzed two times, and obtained data was recorded on specially designed sheets that were prepared in advance. These sheets included data on weight classes, whole duration of match, legal time (two 3-minute), quick and explosive movements,

duration of vigorous activities, efficiency of competitors (placers), and the quality and quantity of obtained scores (1, 2, 4, or 5 points).

In the first analysis, we recorded data consisting of weight classes (all weight categories in GR and FS wrestling were determined by the UWW); whole duration of match (this consisted of all durations, including legal time [two 3-minute], 30-second recovery between periods, video check and injury time-outs, and interval breaks between points); legal time (two 3-minute, although a match may take less than 6 minutes under four conditions: victory by fall, injury, technical superiority, or disqualification); quick and explosive movements (including leg attacks, throws, and even a fast movement of the hands in order to bash the opponent's balance); and duration of vigorous activities (when wrestlers are in contact and trying to take down their rival).

In the second analysis, we recorded the placers' competition efficiency. Placers included GOLD, those who won the gold medal; SILVER, who won the silver medal; BRONZE 1, who lost to the GOLD and won the bronze medal; and BRONZE 2, who lost to the SILVER and won the bronze medal. For this purpose, we gave +1 for actions that ended in a point, 0 for actions that ended in no point, and -1 for actions that caused a loss of point; then we calculated the sum of the given numbers as placers' competition efficiency. Finally, the quality and quantity of obtained scores were recorded.

Analysis of energy systems with use of match durations:

- ATP-PC energy system (ATP): Because of the short and quick nature of explosive movements, we were not able to record the time of these actions accurately with the chronometer. So, we decided to record all of these actions and give 1 second to each of them. Finally, the whole obtained time was counted as ATP.
- Lactic acid energy system (LAC): The recorded time for duration of vigorous activities counted for lactic acid energy system. But before this, we subtracted the ATP duration from duration of vigorous activities, as explosive actions happened within this time.
- Aerobic energy system (AERO): We counted the time of light and moderate activities for this energy system. These activities included the time when wrestlers were not in contact, such as 30-second breaks between periods, breaks between points, and video check and injury time-outs. For this purpose, we subtracted the duration of vigorous activities from the whole duration of the match and counted the obtained time as the time of AERO.

In order to determine the relative contribution of each energy system, we calculated the ratio of time of each energy system to the whole duration of the match.

STATISTICAL ANALYSIS

For description and explanation of the obtained data, we used descriptive statistics (mean and standard deviation) in the form of tables and graphs, and inferential statistics [Kruskal-Wallis H and Mann-Whitney U ($p < 0.05$)] to check the differences between wrestling styles, championships, and placers. Also, we used the Kolmogorov-Smirnov test for normality distribution of data. Excel and SPSS (version 22) software were used to draw the graphs and for data analyzing, respectively.

RESULTS

The average of whole duration and legal time of a wrestling match in different wrestling styles in the 2015 and 2016 WCh are presented in Table 1. Also, the comparison between FS and GR in the 2015 WCh indicated that GR matches take significantly longer in whole duration ($p < 0.05$), whereas there were no significant differences between FS and GR in the 2016 WCh. In addition, comparison between similar weights of FS in the 2015 and 2016 WCh showed no significant differences, but significant differences were observed between similar weight classes of GR, which showed that the 2015 WCh matches took longer in whole duration but not as long in legal time ($p < 0.05$).

Figures 1, 2, 3, and 4 show the relative contributions of energy systems in a wrestling match in different wrestling styles in the 2015 and 2016 WCh. The obtained result of the 2015 WCh showed that FS wrestlers used significantly more ATP than GR wrestlers ($p < 0.05$). The comparison between FS and GR wrestlers in the 2016 WCh indicated that FS wrestlers employed significantly less LAC and more AERO than did GR wrestlers ($p < 0.05$). In addition, when similar weight classes of the 2015 and 2016 WCh were compared separately in each style, results showed no significant differences between FS wrestlers, whereas GR wrestlers in the 2015 WCh employed significantly less anaerobic energy systems (ATP and LAC) and more AERO ($p < 0.05$).

In addition, we investigated the quality and quantity of obtained scores (Figure 5). The comparison between FS and GR in the 2015 WCh showed that the quality of 2-point scores was significantly greater in FS ($p < 0.05$). Also, the quantity of 1-

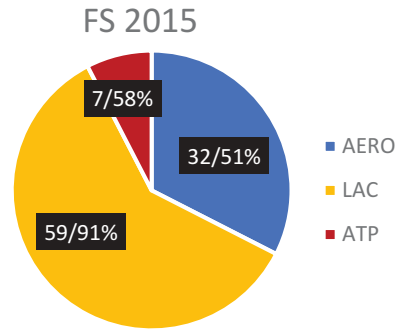


FIGURE 1 Relative contribution of energy systems in freestyle wrestling (2015 WCh).

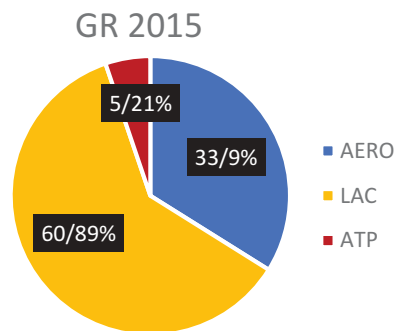


FIGURE 2 Relative contribution of energy systems in Greco-Roman wrestling (2015 WCh).

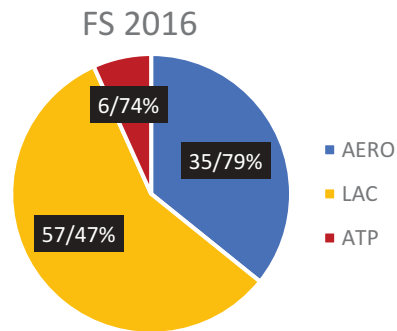


FIGURE 3 Relative contribution of energy systems in freestyle wrestling (2016 WCh).

TABLE 1 Average of Whole Duration and Legal Time of a Wrestling Match (Minute)

Styles	Whole duration	Legal time
Freestyle (2015)	6.58 ± 2.71	4.75 ± 1.79
Greco-Roman (2015)	7.33 ± 2.97	4.86 ± 1.70
Freestyle (2016)	6.79 ± 2.08	5.08 ± 1.50
Greco-Roman (2016)	6.91 ± 1.65	5.42 ± 1.31

point and 2-point scores was significantly greater in FS ($p < 0.05$). In contrast, the quality of 4-point scores was significantly greater in GR in the 2015 WCh ($p < 0.05$). Furthermore, comparison between FS and GR in the 2016 WCh showed no significant differences between these styles in quality and quantity of obtained scores. Finally, we compared the similar weight classes of the 2015 and 2016 WCh separately

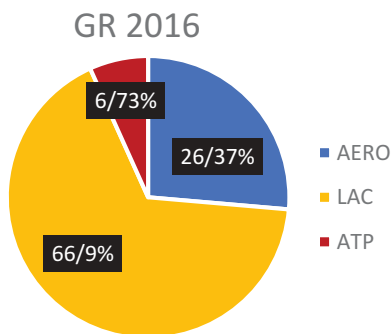


FIGURE 4 Relative contribution of energy systems in Greco-Roman wrestling (2016 WCh).

in FS and GR, and results showed no significant differences in mentioned variables.

Table 2 shows the competition efficiency of FS and GR placers in the 2015 and 2016 WCh. Generally, GOLD had the highest average of competition efficiency, but it was not so for all weight categories. Also, the difference between GOLD and other placers was statistically significant ($p < 0.05$). A comparison between FS GOLD and other placers in the 2015 WCh showed a significant difference between GOLD and SILVER ($p < 0.05$). Also, there were significant differences between GR GOLD compared to SILVER and BRONZE 1 in the 2015 WCh ($p < 0.05$). This study showed no significant differences between FS GOLD compared to other placers in the 2016 WCh, but the average of GOLD competition efficiency was greater than other placers. The obtained result for GR placers in the 2016 WCh showed no significant differences

between GOLD and other placers. The GOLD had a greater average of competition efficiency than SILVER and BRONZE 1, but less than BRONZE 2.

DISCUSSION

As mentioned, the structure of a wrestling match is two 3-minute (6 minute) periods now, but a match may be shorter when a wrestler wins by fall, injury, technical superiority, or disqualification. The present study indicated the whole duration and the legal time of a wrestling match separately in FS and GR styles in the 2015 and 2016 WCh (Table 1). Furthermore, there was no significant difference between wrestling styles in legal time, but significant difference was observed between FS and GR in whole duration of match, which showed that GR matches took longer in the 2015 WCh. This significant difference can be attributed to different rules of these styles. For example, GR wrestlers repeatedly stopped during a match because referees gave passive attention to passive wrestlers; also, offensive wrestlers were asked if they wanted to continue the match in standing or ground position. The result of these actions is prolonging a GR match in whole duration. Moreover, this difference between FS and GR was not observed in the 2016 WCh, and it is obvious that GR rule changes are the reason, because in newly instituted rules by the UWW after the 2016 Olympic Games, passive attentions are given to passive wrestlers without any stops during a match. In addition, FS wrestlers in the 2015 WCh compared to similar weight classes in the 2016 WCh had no significant differences in mentioned variables. In contrast, GR matches in the 2015 WCh took significantly longer in whole duration and less time in legal time comparing similar weight classes in the 2016 WCh. Rule changes are the reason for these differences.

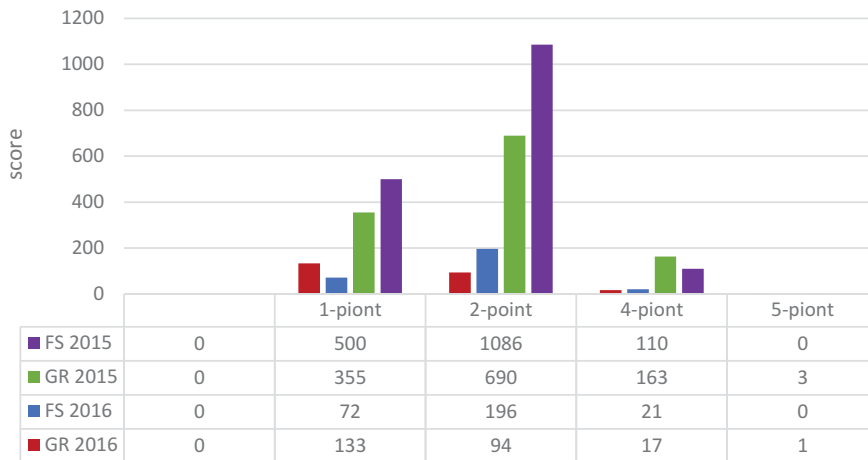


FIGURE 5 Quantity of obtained scores in 2015 and 2016 WCh.

TABLE 2 Values of Competition Efficiency of Placers (Point)

Styles	GOLD	SILVER	BRONZE 1	BRONZE 2
FS 2015	17.87 ± 4.70	12.75 ± 2.54*	14.62 ± 8.70	12 ± 5.52
GR 2015	12 ± 3.38	6.12 ± 2.29*	7.5 ± 3.07*	9.37 ± 4.34
FS 2016	17.5 ± 2.12	13.5 ± 0.70	11.5 ± 6.36	12 ± 1.41
GR 2016	6 ± 1.41	3 ± 2.82	2.5 ± 2.12	9.5 ± 0.70
Average	14.30 ± 5.35	9.20 ± 4.47*	10.25 ± 7.17*	10.70 ± 4.48*

* $p < 0.05$ for significant difference between other placers and GOLD.

There is not a universally accepted method with a direct test for validation to quantify anaerobic energy release, and current methods for quantification of anaerobic energy release are less precise (Gastin, 2001). Because of this, the accurate determination of anaerobic energy release during intense, whole-body exercise continues to pose a problem (Gastin, 2001). Some researchers, such as Horswill (1992) and Mirzaei et al. (2009), have declared that wrestling is anaerobic in nature, and Ohya et al. (2015) declared both anaerobic and aerobic energy systems are employed to various degree in wrestling, but the relative contribution of the three energy systems in wrestling has not been shown in any investigation yet.

It has been shown that relative contribution of energy systems depends on duration and intensity of exercise (Gastin, 2001), which was the main idea of our investigation. The present sample showed relative contribution of ATP, LAC, and AERO during a wrestling match (Figures 1, 2, 3, and 4). The relative contribution of ATP was less than 10%, but it has a determinative role during a wrestling match, because nearly all of the scores are the result of explosive and quick actions. Additionally, our result showed the relative contribution of LAC was about 60%. According to this, it can be calculated that the nature of wrestling is anaerobic, which is in accordance with Horswill (1992) and Mirzaei et al. (2009). Finally, the relative contribution of AERO was about 30%. Of note, we determined the relative contribution of energy systems in a single wrestling match, but not during a wrestling tournament, in which wrestlers have to conduct four to five matches before the final in about 5 hours (Latyshev & Korobeynikov, 2013). Also, rest intervals between third and fourth, fourth and fifth matches may be only 15 to 20 minutes (Latyshev & Korobeynikov, 2013); in these conditions, an ideal aerobic fitness is critical for wrestlers to help them recover.

In the present study, FS wrestlers used ATP significantly more than GR wrestlers in the 2015 WCh. As mentioned, obtained scores are the result of explosive actions (ATP), and the present study showed FS had significantly greater quality in 2-point scores and quantity in 1-point and 2-point scores, which are the reasons to calculate that FS is more dynamic and wrestlers in this style usually choose an attack-oriented strategy. In

contrast, the quality of 4-point scores was greater in GR style, which shows that if wrestlers in this style try to perform more technics, the attractiveness of this style will be much better than what it is now.

Results for the 2016 WCh showed that FS wrestlers used less LAC and more AERO than GR wrestlers. Moreover, the analysis of obtained scores showed no significant difference, but Figure 5 shows that FS wrestlers had a greater quantity of 2-point and 4-point scores; because of this, they had more interval rest time between scores and were less in contact (we counted the time when wrestlers were in contact as the time of LAC), so they employed less LAC and more AERO than GR wrestlers. Also, using more LAC by GR wrestlers and obtaining fewer scores shows that, after implementation of new rules in GR, wrestlers try more in standing position but they gain fewer scores. In addition, many 1-point scores in GR are the result of passive cautions, not technical executions. Also some matches, even some of the finals, ended in no technical point in the 2016 WCh, which shows that the new rules should be reviewed and modified by the UWW.

No significant differences were observed in similar weight classes of FS in use of energy system and quality and quantity of obtained scores between the 2015 and 2016 WCh. In contrast, significant differences were observed in similar weight classes of GR in use of energy systems between the 2015 and 2016 WCh. More analysis indicated GR wrestlers in the 2016 WCh used more LAC and less AERO; as we have already discussed, the reason is rule changes. Also, there were no significant differences between similar weight classes of GR in obtained scores between the 2015 and 2016 WCh.

It should be mentioned that the results of the 2015 WCh were obtained for all weight categories of FS and GR, whereas the results of the 2016 WCh were obtained for only two non-Olympic weight categories in each style (61 and 70 kg of FS; 71 and 80 kg of GR). So, the obtained results of the 2016 WCh may be less precise than obtained results of the 2015 WCh.

The results of this research indicate that GOLD generally had a better competition efficiency than other placers, and the

average of GOLD competition efficiency was statistically significant compared to other placers in both GR and FS. Additionally, Tünnemann (2013) showed that the most powerful athletes are also the best attackers. Furthermore, Tünnemann and Curby (2016), in an investigation of 2016 Rio Olympic Games, showed that nations (Russia, Japan, Cuba, the United States, Turkey, Iran, Armenia, Georgia, Canada, and Serbia) that had the best quality in medals also had the best attack efficacy (except the United States), and this gave a reason to examine the defensive ability of them as well. The result of their investigation showed that there is a good balance between attack and defensive ability in Azerbaijan, Iran, Russia, and Japan, and there are problems in defensive ability in other nations. This greater competition efficiency absolutely is a great advantage for GOLD and could be an important reason for their better results. As shown in Table 2, FS wrestlers had greater competition efficiency than GR. This difference can be attributed to greater complexity of FS, because in FS all techniques that include using arms and legs actively are allowed (Baić, Sertić, & Starosta, 2008).

CONCLUSION

The present study indicated the whole duration and the legal time of a wrestling match. Also, LAC has the most contribution in energy release during a single wrestling match, which represents the anaerobic nature of wrestling. Additionally, our results showed that the nature of FS is more dynamic than GR, because FS wrestlers can use all the GR techniques as well as leg attacks by using arms and legs actively. All in all, GOLD had the greatest competition efficiency compared to other placers in both styles of wrestling.

The results of this study were obtained using recorded videos of the latest World Championships, which were conducted after the last changes in wrestling rules. Also, participating wrestlers in these championships were the best

in the world. Of note, we analyzed and compared wrestling matches and placers using the same method. We hope the results of this study help wrestlers and coaches to design their training programs better, as well as choose a better strategy in their matches.

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