

Time-Motion analysis of the 2017 Wrestling World Championships

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Abstract

Purpose: The purpose of this study was to determine the relative contribution of energy systems in a freestyle (FS) and a Greco-Roman (GR) wrestling match, quantity and quality of obtained scores, and the competition efficiency of winners in the 2017 Wrestling World Championships (WCh) through analysing the recorded videos of all the matches of this event.

Material: The materials of the present study were 295 FS and 266 GR recorded videos of the 2017 WCh, a multimedia player (lap top) for watching and analysing them, and a chronometer for recording the different duration of activities happening during these matches. In addition, special papers were designed in advance to make sure that all the required data were recorded properly.

Results: The percentages of ATP-PC (ATP), lactic (LAC), and aerobic (AERO) energy systems were 6.66, 62.74, and 30.60 in FS, and 5.94, 67.53, and 26.53 in GR. Quantity and quality analysis of scores showed that FS wrestlers significantly scored more 1- and 4-point, while GR wrestlers were superior regarding the quality 2-point. The average competition efficiency of gold medallists was $18/43 \pm 4/67$ in FS and $15/87 \pm 3/18$ in GR which were statistically significantly greater than that of all other placers.

Conclusions: This study showed the dominance of LAC in a wrestling match in both styles, although their relative contribution was significantly different between styles. In addition, FS wrestlers significantly scored more points, and Gold medallists demonstrated the greatest average competition efficiency compared to other medallists.

Keywords: wrestling, energy systems, scores, competition efficiency

Introduction

It is a fact that the Olympic Games and world championships (WCh), with the best athletes from all over the world participating in them, represent the highest quality of sports. Although it is hard to make these championships measurable, time-motion analysis has been used in different kind of sports to provide accurate data of sport events and the movement patterns and activity profiles during a match [1]. These data help coaches better understand their specific sport, investigate the technical and tactical behaviours of top athletes, and even investigate their the physiological and metabolic demands of their sport major [2, 3]. Besides, time-motion analysis provide them with the chance of comparing their athletes with the best in the world [4]. Thus, the information derived from time-motion analysis will assist coaches to develop more effective sport-specific training programs [5].

Wrestling as one of the oldest sports of all times has been done in modern Olympics since 1986 in both freestyle (FS) and Greco-Roman (GR) by men, and women's freestyle (WFS) was also introduced to these games in 2004 [6]. Each of these styles has its own rules and regulations which make them to be viewed as different combat sports [7]. And, this has been of considerable interest by some researchers who tried to further investigate the dissimilarities between these two styles (GR and FS) and also between the physical characteristics of the athletes in each style. For instance,

in a study by Mirzaei et al., they showed that Iranian GR wrestlers significantly obtained better results in Wingate tests, hand grip, chess press, and dead lift, while $VO_{2\max}$ and upper back strength were significantly higher in FS wrestlers [8]. An additional example is the study of Baic et. al., where they demonstrated that FS wrestlers' strength endurance of trunk and upper extremities was statistically significantly more than that of GR wrestlers [9].

There is a considerable amount of information in the sport science literature regarding the relative contribution of three energy systems, namely anaerobic alactic/ATP-PC (ATP), anaerobic lactic (LAC), and aerobic (AERO) mainly because it is a key factor in designing and implementing sport-specific and conditioning programs. Thus, understanding how each of these energy systems works and applies to sport training, and which of them is the dominant one in a certain sport are vital requirements for coaches and instructors [10]. ATP provides energy for explosive and short duration sporting actions taking up to 10 seconds, LAC is responsible for producing energy for actions of relatively longer duration, 15 to 60 seconds, and AERO is employed to produce energy in sports ranging from one minute to more than three hours [10, 11]. However, while, with this description of energy systems, it seems easy to determine where a sport major falls in the continuum of energy systems contribution, it requires an especial consideration when considering a sport with intermittent nature, for example, wrestling, boxing, team sports, mixed martial arts, and so on. More specifically, in the active part of these sports energy is produced by anaerobic pathways (ATP and LAC), whereas

they strongly rely on aerobic energy system during the short recovery periods between actions [10]. To the best of our knowledge, the only study which determined the relative contribution of the energy systems in wrestling is an investigation conducted by Mirzaei et al., in which they also showed that there were significant differences between GR and FS in the employment percentage of each energy system [12].

Another advantage of time-motion analysis is scoring analysis which leads to a better understanding of winners' competition efficiency, attack and defence efficacy, obtained scores, common used techniques, etc. These information deliver important benefits to coaches in order to incorporate this knowledge into their training routines and improve their athletes' technical and tactical acquisition [13]. For instance, Mirzaei et al., showed that FS wrestlers generally scored more points than what GR wrestlers did in the 2015 WCh, and the total number of 1- and 2-point scores was greater in FS while that of 4- and 5-point scores was greater in GR [12]. It is also noteworthy to mention that all these technical and tactical variables are significantly influenced by rule changes which usually happen after each Olympic Games [12]. A clear example of the impact of these changes can be seen in a long-term analysis of world and Olympic championships by Tunnemann [3]. He showed that the number of technical points scored per minute had a clear downtrend since 2005, and then it hit a bottom in the 2012 Olympic Games, where it was even possible to get a win by a totally defensive strategy, but after the 2013 rule changes there was a considerable increase in the number of points scored per minute [3].

Therefore, the objectives of this study were 1) to determine the relative contribution of energy systems in a single wrestling match of the 2017 WCh, 2) to determine the total quantity and quality of obtained scores in FS and GR in the 2017 WCh, 3) to determine the competition efficiency of the 2017 WCh medallists, 4) to compare the mentioned variables (1, 2, and 3) between GR and FS to further investigate these styles' differences, and 5) to demonstrate the impact of the rule changes after the 2016 Rio Olympic Games on these variables (1, 2, and 3).

Material and Methods

Sources of information.

The videos of all matches of the 2017 wrestling WCh (295 and 266 videos in GR and FS respectively), which were posted on the UWW website, a multimedia player (lap top) to watch and analyze the videos, and a chronometer to record the duration of activities during wrestling matches were the materials of the present study. In order to make sure that all the desired data were recorded properly, especial papers were designed, and all the data were noted in its specific section.

Research Design.

Each video was analyzed two times. During the first analysis weight classes (FS: 57,61, 65, 70, 74, 86, 97, 125; GR: 59, 66, 71, 75, 80, 85, 98, 130), whole duration of a match (from start to the end), legal time that is

two 3 minutes with 30 seconds rest between, quick and explosive movements (all the performed techniques, and fast movements of both legs and hands), and duration of vigorous activities that is the active part of a match when wrestlers are struggling were recorded. During the second analysis competition efficiency of winners who were gold medallist (GOLD), silver medallist (SILVER), and the two bronze medallists (BROMZE 1 and 2 who lost to GOLD and SILVER respectively) was recorded. With respect to competition efficiency, +1, 0, and -1 were respectively given to the actions resulted in point, no point, or point loss, and the sum of them was considered as the athletes' competition efficiency. Finally, the scores quality (percentage of 1-, 2-, 4-, and 5-point) and quantity (number of 1-, 2-, 4- or 5-point) separately in FS and GR were recorded.

As the relative contribution of energy systems directly depend on the intensity and duration of sporting actions, recorded durations of difference activities happening in a wrestling match were used to determine the relative contribution of three energy systems: to determine the relative contribution of ATP-PC energy system (ATP), all the explosive actions were recorded. Then each of them was counted as one second as Blais et al. showed that performing a technique in combat sports can be as short as 1 second [14]. And, the sum of them was considered as the total time of this energy system. This time was subtracted from the time of vigorous activities and the remained seconds were counted as the time of lactic acid energy system (LAC). This subtraction was done as the explosive actions had happened within the time of vigorous activities. Finally, the time when wrestlers were not in contact, such as breaks between periods and points, video check and injury time-outs, and any other time when wrestlers were not in contact was devoted to aerobic energy system (AERO). For this purpose, we subtracted the time of vigorous activities from the whole duration of a match. Finally, the time ratio of each energy systems to the whole duration of a match revealed the relative contribution of each energy system.

Statistical analysis.

Descriptive statistics (mean and standard deviation) in form of tables and graphs was used to describe and explain data, and inferential statistics (Kruskal-Wallis H and Mann-Whitney U with a significantly level of $p < 0.05$) was used to determine the differences between FS and GR, and the competition efficiency of placers. In addition, the normality distribution of data was tested using the Kolmogorov-Smirnov Test. The software used for drawing the graphs and analysing data were Excel and version 22 of SPSS respectively.

Results

The average of the whole duration and the legal time of a wrestling match in different styles of the 2017 WCh is represented in Table 1, and the comparison between these two styles showed a significant difference in the legal time ($p < 0.05$). More specifically, the FS matches took shorter than the matches in GR.

Table 1. The average of the whole duration and the legal time of a GR and a FS match in the 2017 WCh (minute)

Styles	Whole duration	Legal time
Greco-Roman	7.43±2.08	5.41±1.36*
Freestyle	7.34±2.49	5.02±1.08

* - shows the significant difference between GR and FS (p < 0.05)

Figures 1 and 2 show the relative contribution of energy systems in a GR and a FS match, respectively. The comparison between these styles demonstrated that ATP and AERO were significantly more employed in FS (p<0.05), while LAC employment showed to be significantly higher in GR (p<0.05).

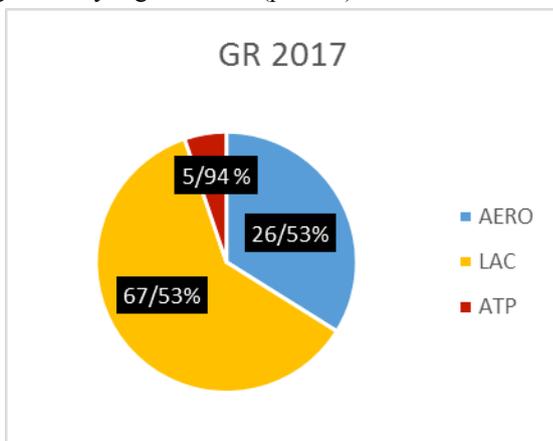


Figure 1. Relative contribution of energy systems in a GR match of the 2017 WCh (percent)

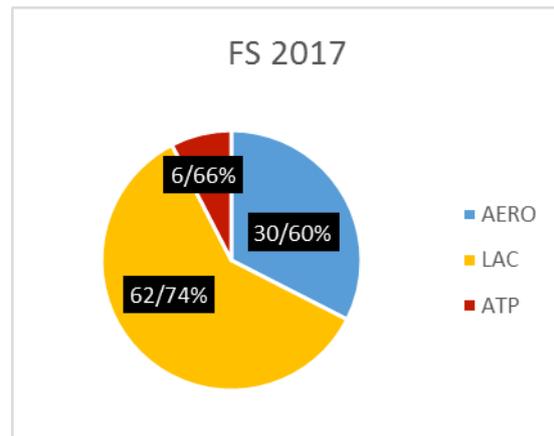


Figure 2. Relative contribution of energy systems in a FS match of the 2017 WCh (percent)

The obtained scores are presented in both quantity and quality in Table 2. The comparison of the quantity demonstrated that FS wrestlers significantly scored more 1- and 4-point than GR wrestlers, and the quality comparison showed a significant difference in 2-point percentage, which was higher in GR (p<0.05).

The average competition efficiency of placers is presented in the following table (Table 3). In general, GOLDS had the highest values in both styles, which were significantly higher than that of other placers (p<0.05). Besides, SILVERs showed to have the second highest values, which were higher than both bronze medallists, but only statistically significantly higher than BRONZE 2 (p<0.05). Although the competition efficiency of BRONZE 1 was higher than BRONZE 2, there was no significant difference between them (p<0.05).

Table 2. Quantity (number) and quality (percent) of the obtained scores in GR and FS in the 2017 WCh

Styles	Criterion	1-point	2-point	4-point	5-point
Greco-Roman	Quantity	361	567	102	2
	Quality	34/02	55/70*	10/08	0/18
Freestyle	Quantity	505*	755	279*	0
	Quality	33/78	47/98	18/12	0

* - shows the significant difference between GR and FS (p < 0.05)

Table 3. The average of placers' competition efficiency in the 2017 WCh (point)

Styles	GOLD	SILVER	BRONZE 1	BRONZE 2
Greco-Roman	15/87±3/18	10/87±4/05*	8/25±3/53*	6/87±1/55*†
Freestyle	18/43±4/67	12/93±4/05*	10/12±4/54*	7/31±2/27*†

* - shows the significant difference between GOLD and other placers, † - shows the significant difference between SILVER and BRONZE 1 and 2, and shows the significant difference between BRONZE 1 and 2 (p < 0.05)

Discussion

The present study was carried out to find answers of aforementioned five questions, and the obtained results are going to be discussed in this section. The first finding of this study was the average value of the whole duration and the legal time of a wrestling match which is represented in Table 1. The whole duration of a match includes the time from start to end of it, and the legal time is now two 3 minutes with 30 seconds rest between. The latter could take shorter under four conditions, including technical superiority (a difference greater than 8 points in GR and 10 points in FS), victory by fall, injury, and/or disqualification of one of the wrestlers [12]. The result of this study showed a significant difference between GR and FS regarding the legal time which illustrated that in general FS matches took shorter than GR ones (FS: 5.02 ± 1.08 vs. GR: 5.41 ± 1.36). This could be because of the higher number of points scored in FS, as a result more matches ended with technical superiority. However, in the same analysis of the 2015 WCh by Mirzaei et. al., they showed that the whole duration of GR matches was significantly longer than that of FS (GR: 7.33 ± 2.97 vs. FS: 6.58 ± 2.71), and there was no significant difference in the legal time between them (GR: 4.86 ± 1.70 vs. FS: 4.75 ± 1.79) [12]. They explained that the reason for this difference was the GR rules as referees used to give passive cautions to passive wrestlers by repeatedly stopping the match, resulting in a longer whole duration [12]. This rule was eliminated after the 2016 Rio Olympic Games [12]. Yet, this cannot explain the result of the present study which did not show a significant difference between the styles regarding the whole duration. Although the mentioned rule was no longer existed in the 2017 WCh, the whole duration of the GR matches did not show any decrease, and actually it was the increase in the whole duration of the FS matches which almost equalled that of GR and was responsible for no significant difference between them. In conclusion of this section, the whole duration and the legal time of a wrestling match is significantly different between the GR and FS, and these values could be affected by the rule changes happening after each Olympic Games.

Another major finding of the present study was estimation of the energy systems' relative contribution that is the base element for designing an effective conditioning program. And, it was carried out through measuring and recording the activities with different modes, intensities, and durations during a single wrestling match. The obtained result showed that the anaerobic lactic energy system predominates a wrestling match with a value of 67.53% and 62.74% in Greco-Roman and Freestyle respectively (Figure 1 and 2). It has been mentioned in the literature that wrestling is anaerobic in nature [6, 12, 15]. Moreover, Bompa supposed that anaerobic energy systems together are responsible for providing around 60% of the energy cost in wrestling [10], and Fukuda et al., said that anaerobic power and capacity are the primary elements for success in wrestling [16]. All these are in accordance with our findings. Still, the contribution of the energy systems in wrestling was not quantified until

Mirzaei et. al. analyzed the 2015 WCh and determined the proportion of each energy transfer system in a wrestling match [12]. After LAC, having the greatest contribution, aerobic and anaerobic alactic energy systems have the second and third greatest values with 26.53% and 5.94% in GR and 30.60% and 6.66% in FS respectively. The same order but not the same percentages was also shown by Mirzaei et al. [12]. However, while the priority of these three energy systems are in the same order in both styles, further investigations showed significant differences between GR and FS regarding the employed percentage of each of them. More specifically, the employment of LAC was significantly greater in GR which is an indication of these wrestlers' constant effort especially in the stand position. This could be due to two reasons. First, passive cautions are given to GR wrestlers as the match continues, and second, a smaller number of points scored in GR means less interval rest between them. On the other hand, ATP and AERO showed to be significantly larger in FS wrestling. Of note, ATP produces energy for the quick and explosive actions that are decisive in this sport because the obtained scores are the result of these actions; besides, as it was already mentioned, after scoring a point there is a short period of pause that uses AERO in order to recover the energy sources, creatinine phosphate in particular [17]. Therefore, the higher relative contribution of these two energy systems is clearly due to the higher number of points scored by wrestlers in this style. So, it could be concluded that putting an effort to gain a point not only exhausts one and decreases the quality of their performance but also rewards them by a period of active rest which even help them to be more active and gain more points. In another study by Campos et al., they investigated the energy systems contribution and energy costs during a taekwondo combat [17]. Their method consisted of measurement of oxygen consumption, the fast component of excess post-exercise oxygen consumption, and the change in blood lactate concentration in order to estimate the contribution of AERO, ATP, and LAC energy systems, respectively [17]. They showed that during a taekwondo match energy was provided $66 \pm 6\%$ by AERO, $30 \pm 6\%$ by ATP, and only $4 \pm 2\%$ by LAC, which showed the total predominance of the aerobic energy system in this sport [17]. The difference between their findings and the result of the present study could be attributed to the fact that in taekwondo athletes are not in contact, and they approach each other only when they want to strike a kick or a punch, whereas in wrestling athletes are in direct contact for almost the whole legal time (6 minutes). Besides, wrestlers have to bend their knees and body, bear their own body weight, and tolerate the pressure exerted by their opponent, who attempts to push them out of the mat or throw them off balance. The powerful contractions, isometric and quasi-isometric ones in particular, happening in these situations cause blood vessels occlusions within the contracted muscles, as a result, oxygen cannot be delivered to the cells and metabolite by-products cannot be removed [18]. Thus, the energy production shifts from aerobic to anaerobic. To sum up, the sport of wrestling

either in GR or FS is anaerobic in nature. Even though the order of energy systems is the same in both styles, there are significant differences between them regarding the energy systems' relative contribution, and rule changes could influence these proportions.

In addition to the mentioned findings, investigating the total quantity and quality of obtained scores in both styles is another main outcome of the present study. As you can see in Table 2, the total quantity of 1-, 2-, and 4-points are clearly greater in FS with the exception of 5-point being greater in GR. And, two of these differences that are 1- and 4-point are significant. Furthermore, compared to the GR result of the 2015 WCh, 1-point shows 6 number increase, while there are decreases with the magnitudes of 123, 61, and 1 regarding 2-, 4-, and 5-point respectively [12]. This shows that the upward trend in number of points seen by Tunnemann (2016) after the 2013 rule changes experienced a considerable reduction when the 2016 rule changes was applied to this style [3]. This could negatively affect the attractiveness of this style. On the other hand, compared to the 2015 FS WCh, the result of the 2017 FS WCh showed quantity increases in 1- and 4-points with the magnitudes of 5 and 169 respectively, while that of 2-point decreased by 331 numbers. And, the quantity of 5-point was 0 in both championships. This greater number of scores in FS could be attributed to the fact that techniques targeting both upper and lower body are allowed in FS while GR involves only techniques at the upper body [16]. We calculated the total sum of points (sum of the quantity of each point multiplied by its value [1, 2, 4, and 5]) in both years to better understand the difference between them. And, the result (2015: 3112 vs. 2017: 3131) showed a negligible rise of 19 points in the 2017 FS WCh. However, the more important finding of this comparison was the substantial growth of 4-point techniques which are the most important element of the attractiveness of this sport. Additionally, the quality of the scores was in the same order in both styles with 2-point being the greatest and then 1-, 4-, and 5-points being the next ones respectively. The only significant difference in this regard was the quality of 2-point which showed to be greater in GR. This is in the contrast with the result of Mirzaei et al., who showed that the percentage of 2-point was greater in FS, and that of 4-point was greater in GR in the 2015 WCh [12]. Again, this shows that the attractiveness of GR is reducing whereas it is improving in FS. Like other findings of the present study, GR and FS showed to be different in these variables as well, and the 2016 rule changes had a significant impact on them.

The final finding of the present study is the average competition efficiency of the winners in both GR and FS (Table 3). The result showed that the gold medallists of both styles statistically significantly had the greatest competition efficiency compared to other placers. In addition, the second greatest values belonged to the silver medallists, and there were significantly more than that of BRONZE 2. However, there were no significant difference between BRONZE 1 and 2, even though the competition efficiency of BRONZE 1 was higher. In the study of

Mirzaei et al., they showed that the average competition efficiency of gold, silver, bronze 1 and 2 medallists was 12 ± 3.38 , 6.12 ± 2.29 , 7.5 ± 3.07 , and 9.37 ± 4.34 in GR and 17.87 ± 4.70 , 12.75 ± 2.54 , 14.62 ± 8.70 , and 12 ± 5.52 in FS, respectively [12]. They have only compared GOLD to other placers and showed that in GR it was significantly greater than SILVER and BRONZE 1, while in FS it was only greater than that of SILVER but not bronze winners [12]. As you can see, the values resulted from their study were not in a logical order. Actually, the values of bronze medallists have appeared to be greater than SILVER and had no significant difference with GOLD. However, in the present study as the rank of placers decreased so did their competition efficiency. This could be attributed to the seeding system that was applied to the 2017 WCh for the first time in the history of this sport. According to this system, top four seeds were determined by the points awarded to wrestlers who competed in the 2016 Olympic Games, 2016 non-Olympic weight classes World Championships, and the 2017 Continental Championships [19]. Then they were separated in order to guarantee premier semifinal and final matchups [19]. Thus, top wrestlers were given the chance of competing lower rank athletes, and this might be the reason of their competition efficiency improvement especially in GR.

Another advantage of this system is that all the top athletes have the chance of winning a medal which was not possible before as there was a possibility that all four top wrestlers be in the same half of the table. In another study by Tunnemann and Curby, which was an investigation of the 2016 Olympic games, they showed that not only the athletes who had a better attack ability obtained a better result but also there was a good balance between the attack and defence abilities of the wrestlers from top nations, such as Azerbaijan, Iran, Russia, and Japan [20]. The difference between GR and FS is also clear in this variable, and also the effect of the application of the new rules.

Conclusion

The present study determined the average time of which a GR and a FS match takes from start to end as well as the actual duration of the legal time of both styles. In addition, there were significant differences between Greco-Roman and Freestyle regarding the relative contribution of energy systems. However, the glycolytic energy system was the dominance one in a single wrestling match in both styles. The quantity of the obtained scores in Greco-Roman style experienced a substantial reduction, while in Freestyle the number of points showed a considerable increase and most of it was as the result of the rise in 4-point scores. Furthermore, it seems that seeding system had a positive effect on the competition efficiency of the placers. Additionally, it must be mentioned that the 2017 WCh was analyzed by the same method that was used by Mirzaei et al. (2017), to analyze the 2015 WCh. This makes our comparisons more reliable. Moreover, the level of the 2015 and 2017 Wrestling World Championships could be different

due to the fact that the 2015 WCh was the year before Olympic Games when wrestlers try to become qualified for participation in these games and confront their best opponents; on the other hand, in the year after the Olympic Games, top wrestlers may prefer not to participate in the world championships. Finally, all the measured variables in this study showed to be significantly different between

the GR and FS, and the difference between the 2015 and the 2017 WChs indicated the impact of rule changes after the Olympic Games.

Conflict of interests

The authors declare no conflict of interests.

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