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# Heart Rate Variations in an Elite Futsal Player after Twelve Years of Maximum Performance

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**Abstract** Compare cardiovascular responses and adaptations of a professional futsal player both at rest and in action over an uninterrupted twelve-year period. Cross-over case study. Data analysis was performed by descriptive analysis, which results are expressed as percentages (percentiles) and mean ± standard deviation (SD). The study was conducted between 1999 and 2012 sport seasons. Laboratory tests (Electrocardiogram and echocardiography, maximum stress test) and field test (competitive and training games).The VO2 max of our athlete decreased from 57.8 to 52.7 ml/kg/min however the anaerobic threshold significantly improved, as it increased from 80.4% to 92% of his heart rate maximum (HRmax). The athlete's HRmax changed from 194 bpm in 1999 to 176 bpm in 2012 and his mean heart rate (MHR) from 168.1 ± 13 bpm to 142 ± 13 bpm. In 1999 the athlete's performance was < 150 bpm 9.1% of time while in 2012 his heart rate (HR) was < 150 bpm 60.30% of time. In 1999, he had 150-170 bpm 32.9% of time, while in 2012 he was 39.7% of time with this HR. He changed from having a HR >170 bpm 57.8% of time in 1999 to not have this HR at any time in 2012. Comparative analysis indicated that intensity variability over a decade is < 10%, as it was 86.5% in 1999 and 80.6% in 2012. Conclusions: Age is the main factor causing heart rate variability in team sports players since maximum heart rate decreases with age. Using heart rate as an indicator of work intensity involves using relative values of percentage of work intensity with respect to their maximum heart rate.

***Keywords:*** *team sports, adaptations, training, fitness, cardiovascular responses*

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## 1. Introduction

Heart rate (HR) is widely accepted as an indicator of cardiovascular response [1,2,3] in many sports –including team sports– and is used for training load control [4-9]. The reason to using HR is that it can be easily measured, recorded, read and functionally applied. Moreover, it is a non-invasive parameter easily measurable by performance assessment teams.

HR variations have been reported in athletes performing the same work [10]. Such variations might be due to different causes, being the most relevant the age, competitive level and motivation of the athlete [11]. HR variations are greater in team sports as a result of individual playing style, playing positions, etc [12].

Researchers have found individual differences in the physiological profile of different sports modality players. However, scarce literature is available on the evolution of intrapersonal HR variations throughout a sports career.

In 1999 [13] we examined the physiological profiles of two futsal players: a young player performing at a very high HR, and an older player playing at a low HR. The profiles obtained led us wonder whether young players performing at so great absolute intensities maintain the same HR response over the years. To answer this question we conducted a ten-year follow-up study on a professional male futsal player. Accordingly, the aim of this study was to compare the cardiovascular responses and adaptations of a professional futsal player both at rest and in action over an uninterrupted ten-year period.

## 2. Material and Methods

This is a cross-over case study conducted between 1999 and 2012. Data analysis was performed by descriptive analysis, which results are expressed as percentages (percentiles) and mean ± standard deviation (SD).

The athlete provided informed consent to undergo all stress tests and was aware that he could quit the study at any moment.

As to the specific characteristics of the athlete, he did not have any relevant injury at any moment throughout the study period.

The first record was taken in 1999, when the athlete was 19 years of age, and the last was taken in the 2011-2012 season.

Futsal is an intermittent game based on brief intense actions interspersed by active and incomplete recovery periods including a sequence of highly demanding aerobic-anaerobic actions [13], where players frequently perform maximally [14].

This case study included the following studies:

Kinanthropometry: Height (cm) was measured by a 1-mm precision stadiometer “Seca”. Weight was assessed by a 100g.-precision scale. Six skinfolds (mm) were measured with a “Holtain Crymich” 0.1 mm- scaliper.

Electrocardiograms and echocardiographies: We performed 12-lead electrocardiograms (Fukuda-Denshi FK-12) and echocardiographies (Ecocardiografo-Dopler “Hewlett Packard”) with the subject at rest. These two tests were performed to find out whether professional training induces a different cardiovascular response at rest because of an adaptation of the heart. Electrocardiograms and echocardiographies were performed and read by the same observer.

Maximum stress tests were performed on a treadmill (Jaeger-LE5, Wuerburz, Germany): To determine the athlete’s HR values and response to progressive-maximum stress we established work thresholds with a continuous progressive protocol set at a fixed 3% slope and 1 Km.h-1 load increases at 1-minute intervals. Pulmonary air flow and gas exchange were analyzed breath by breath (Medical Graphics CPX/MAX, St. Paul, Minnesota, USA).

We considered that maximum oxygen uptake (VO2 max) was reached:

When the oxygen uptake (VO2) although the training load was increased.

When the mean heart rate was > 90% of HR for age (220-age).

And when the gas exchange rate was > 1.15.

The ventilatory threshold was determined during stress tests by the V-Slope method [15].

Heart rate maximum (HRmax): Different studies indicate that HRmax is an individual parameter which is not sensitive to fitness status and is not affected or slightly affected by age, heredity etc. However, there are other factors such as fatigue, motivation or stress that may alter HRmax values [12]. At 32 years of age, the HRmax begins to decrease linearly. To determine the HRmax we used the maximum value obtained either in the laboratory test or during a game. The reason is that according to Barbero some players may have two or three more beats during a game than in lab tests [16,17].

Heart rate (HR) recorded in competitive and training games. We recorded the athlete’s HR in eight matches – four throughout the 1999-2000 season and four throughout the 2011-2012 season. We considered that the sample size was appropriate as the results obtained were consistent with those obtained in previous studies [10,18]. Thus, previous studies have reported that HRmax values and mean HR (MHR) do not significantly vary from match to match, and each player has their own repeating performance pattern. Data were collected in the same conditions: type of work (futsal games); day time (in the afternoon); place and environmental conditions (indoor court); and constant hydration, since losing 1% of body weight negatively affects performance.

HR was measured using Polar heart rate monitors –the Accurex Plus model in 2000 and the 725X model in 2011– set to record HR at five-second intervals. The data collected in the field study were analyzed using the Polar Pro trainer interface.

It is noteworthy that two of the most relevant variables affecting HR –cognitive and emotional factors [19] – have changed over time.

# 3. Results

## 3.1. Laboratory Tests

In 1999: Age: 19 years old. Weight: 82.5 kg. Height: 181cm. ∑6skinfolds: 60.3 mm. Maximum oxygen uptake: 57.8 ml/kg/min. Loud reached in Maximum stress test 16 Km/h. Anaerobic Threshold: 156 bpm. HRmax: 194 bpm. Anaerobic Threshold % HRmax: 80.4%.

In 2012: Age: 32 years old. Weight: 84.1 kg. Height: 181.8 cm. ∑6skinfolds: 60.6 mm. Maximum oxygen uptake: 52.7 ml/kg/min. Loud reached in Maximum stress test 17 Km/h. Anaerobic Threshold: 162 bpm. HRmax: 176 bpm. Anaerobic Threshold % HRmax: 92.0%.

## 3.2. Competitive and Training Games

Cardiovascular response (Figure 1) and Work intensity by the percentage of maximum heart rate (Table 1):

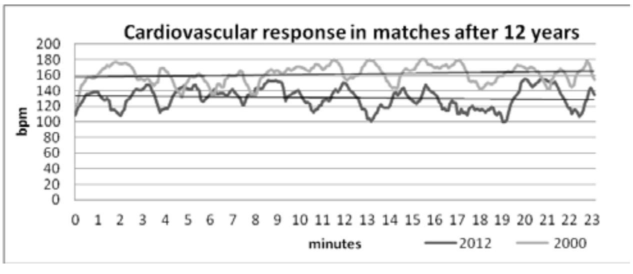


**Figure 1.** Cardiovascular response in matches after twelve years

**Table 1. Cardiovascular response in matches**

| Season 1999-2000 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MHRa | %HRmaxb | >100 | 100-109 | 110-119 | 120-129 | 130-139 | 140-149 | 150-159 | 160-169 | 170-179 | 180-189 | 190-199 |
| 167±14 | 86.1 | 0.8 | 0 | 0.8 | 0.8 | 1.8 | 3.9 | 12 | 28.6 | 38 | 13 | 0.3 |
| 162±12 | 83.5 | 0.6 | 1 | 1.8 | 4 | 3.8 | 7 | 18.1 | 22.1 | 30.1 | 11.4 | 0 |
| 170±14 | 87.6 | 0.7 | 0.3 | 0.7 | 1.7 | 0.1 | 3.7 | 5 | 18.3 | 47.3 | 22.3 | 0 |
| 172±13 | 88.6 | 0 | 0.3 | 0.3 | 0.3 | 0.3 | 1.8 | 6.3 | 21.4 | 41.6 | 27.7 | 0 |
| 168±13 | **86.5** | **0.5** | **0.4** | **0.9** | **1.7** | **1.5** | **4.1** | **10.3** | **22.6** | **39.2** | **18.6** | **0.1** |
| **Season 2011-2012** | | | | | | | | | | | | |
| MHRa | %HRmaxb | >100 | 100-109 | 110-119 | 120-129 | 130-139 | 140-149 | 150-159 | 160-169 | 170-179 | 180-189 | 190-199 |
| 131±1 | 74.3 | 0.0 | 4.3 | 21.9 | 18.6 | 25.4 | 21.1 | 8.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| 127±17 | 72.1 | 0.0 | 21.3 | 13.6 | 21.3 | 19.2 | 13.3 | 5.9 | 5.2 | 0.0 | 0.0 | 0.0 |
| 145±15 | 82.3 | 0.0 | 1.6 | 8.0 | 9.2 | 13.0 | 18.5 | 35.2 | 14.4 | 0.0 | 0.0 | 0.0 |
| 139±13 | 78.9 | 0.0 | 3.0 | 8.0 | 16.7 | 19.5 | 23.1 | 26.8 | 3.0 | 0.0 | 0.0 | 0.0 |
| 142±14 | **80.6** | **0.0** | **2.3** | **8.0** | **12.9** | **16.2** | **20.8** | **31.0** | **8.7** | **0.0** | **0.0** | **0.0** |

In 1999: HRmax was 194 bpm. In maches the work intensity by the percentage of HRmax was 86.5%. The player were <65% of their HRmax 2.8% of time; between 65-85% of their HRmax 31.6% of time, and >85% of their HRmax 65.5% of time.

In 2012: HRmax was 176 bpm. In maches the work intensity by the percentage of HRmax was 80.6%. The player were <65% of their HRmax 6.3% of time; between 65-85% of their HRmax 69.0% of time, and >85% of their HRmax 24.7% of time.

# 4. Discussion

## 4.1. Laboratory Tests

*Anthropometric characteristics:* Although the athlete changed from 82.5 to 84.1 kg of weight, his anthropometric characteristics did not change significantly over the 12-year study period. The reason is that in twelve years the athlete grew nearly one centimeter, and during the holidays the subject usually weighs one kilo more than during the pre-season ten years ago.

*Electrocardiogram-echocardiography:* In our study of the 1999 season [14] we found that over 80% of futsal players had sinus bradycardia. This is the case of our subject, who in 1999 presented a HR of 55 bpm at resting position and 45 bpm in 2012. The remaining parameters on the Electrocardiogram-echocardiography remained stable over the ten years and are similar to those found in similar sports players [20].

*Maximum stress tests* were performed at the beginning of the pre-season i.e when the player was not in his optimal fitness status. We found that, in spite of the years, the athlete maintained almost the same VO2 max, which was only slightly lower than ten years before. In addition, the athlete could endure greater training loads.

Maximal oxygen uptake (VO2 max): Firstly, we should take into account that VO2 max is not a limiting factor for maximal performance [21]. The reason is that the type of work performed in futsal is intermittent and correspond to short high-intensity training exercises that require high-intensity work. These methods involve a relatively low load to circulation and breathing by the introduction of brief sprinting-and-rest intervals appropriately separated (microbreaks). This physiological concept allows for older subjects or individuals with a lower VO2 max to perform intense work provided that work and recovery periods are appropriately regulated.

The VO2 max of our athlete decreased from 57.8 to 52.7 ml/kg/min, which is consistent with the findings of previous studies that suggest that the average rate of decline is 10% per decade after the age of 25. Increasing VO2 max is difficult. In fact, trained people only can increase their VO2 max by 10% approx [22]. The 52.7 ml/kg/min value obtained in this study in 2012 is lower than the value obtained in previous studies on futsal players (57.80±2.53 ml/kg/min) [21]. However, we think

that such differences wouldn't exist if we had measured VO2 max during the in-season as in the referenced study. The values obtained in this study are consistent with those found in team sports players [21]. Thus, values < 50 ml/kg/min are considered deficient; between 50 and 55 ml/kg/min. are normal; 55-60 ml/kg/min. are good and > 60 ml/kg/min. are excellent VO2 max values.

*HRmax:* The athlete's HRmax decreased from 194 bpm in 1999 to 176 bpm in 2012, which accounts for a decline of 20 bpm approx. The age range of team sports players is wide as players can be 18-36 years of age. Consequently, their HRmax values also vary significantly, since age –and individual adaptation to stress– is directly related to HRmax. These two factors –age and individual adaptation– are the main cause of HR variations among team sports players undergoing the same stress.

*Anaerobic threshold:* Is the most reliable performance indicator and one of the primary goals of training. It can be increased by a maximum of 40% [23]. Training seasons are intended to make players progressively become more resistant to fatigue and increase their energy use, which can pass from 60% to 90% [24]. The anaerobic threshold of the player in our study significantly improved, as it increased from 80.4% to 92% of his HRmax, which accounts for a significant adaptation to high-intensity stress.

The VO2 max and anaerobic threshold values obtained in this study are consistent with those obtained by Parr et al. (1978) [25], who observed that although basket players do not present high oxygen uptake values, their anaerobic threshold is greater as compared to that of other sports players with a similar VO2 max.

## 4.2. Competitive and Training Games

*Mean heart rate (MHR):* Futsal is an indoor court sport with few players that is played in a small area with a limited number of changes. Consequently, all players perform considerable work and are in constant movement to search for spaces. When a player does not work with enough intensity, he is replaced with another player. As unlimited changes are allowed, futsal players present high MHR, as described in previous studies [13,16]. During a game, futsal players are 83% of time >85% of their HRmax, which is considered by Woolford and Argove [26] and the ACSM as a very vigorous intensity [17].

Accordingly, interpersonal HR variability is very important, and the dispersion of values around the mean HR value is very high. This was proven by Alvarez [10], who established a mean HR value of 165±10 bpm and a range of 141-181 bpm. Another study examining the HR of eight futsal players at the Division de Plata (second professional league) in five matches yielded a mean HR of 172.9±0.8 bpm [27].

The cardiovascular response of the athlete in our study changed over time. HR was always measured in the same conditions. The only factor that changed was the athlete's age and cognitive and emotional factors [19].

*Age:* The athlete's HRmax declined by 20 bpm approx. and his MHR changed from 168.1±13 bpm to 142±13 bpm. MHR should be associated with HRmax, which accounts for work intensity.

*Cognitive and emotional factors:* In 1999, the athlete was at the beginning of his professional career and wanted to earn a position in the team, so his performance was maximal in training sessions and competitive matches. After a decade, our athlete became a veteran player and had his place in the team, so he regulated his actions and avoided unnecessary stress, which reflects a better understanding of the game. In other words, he economized stress.

These data confirm that HR can be used as an indicator of stress provided that HRmax is related to relative intrapersonal intensity values rather than to absolute values.

*HR distribution ranges (Figure 2):* In 1999 the athlete's performance was < 150 bpm 9.1% of time while in 2012 his HR was < 150 bpm 60.30% of time. In 1999, he had 150-170 bpm 32.9% of time, while in 2012 he was 39.7% of time with this HR. He changed from having a HR >170 bpm 57.8% of time in 1999 to not have this HR at any time in 2012. These results are in agreement with those obtained by Barbero (2004) [16, 27], who found that players were <150 bpm 6.9% of time; 150-170 bpm 25.7% of time; and >170 bpm 67.4% of time during a match.

A possible explanation to this might be that the Barbero study was performed on players at the Division de Plata, where players are prevailingly young and have greater motivation and HRmax as compared to older players. This is confirmed by their HRmax, which were 192.1±0.8 bpm.

The decline in HR is not caused by a reduction in work intensity, but to the player's current inability to work at such a high HR due to a decline in his HRmax.

*Work intensity by the percentage of HRmax:* The results obtained in 1999 were similar to those reported by Barbero [16,27], who determined that futsal players are <65% of their HRmax 1.8% of time; between 65-85% of their HRmax 15% of time, and >85% of their HRmax 80.70% of time.

Comparative analysis indicated that intensity variability over a decade is < 10%, as it was 86.5% in 1999 and 80.6% in 2012.

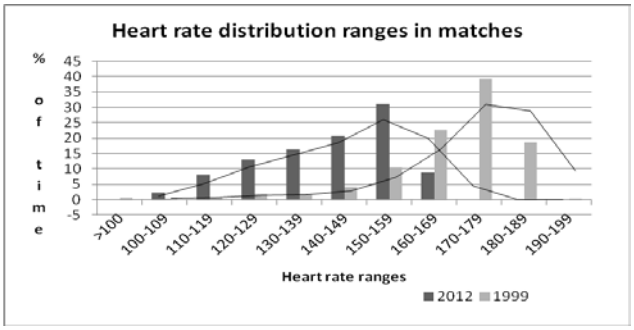


**Figure 2.** Heart rate distribution ranges in matches

We analyzed the interpercentile interval 65-85% – which is the interval used for the classification of training loads in team sports– and observed a significant increase in the 12-year study period. However, when we analyzed the 85% percentile we found a significant decrease [28]. The data obtained clearly show that the time spent at each intensity interval has changed over the years. Our athlete performed at < 65% of his HRmax 2.8% of time in 1999 and 6.3% in 2012. He played between 65-85% of his HRmax 31.6% of time in 1999 and 69% in 2012. He performed at > 85% of his HRmax 65.5% of time in 1999 and 24.7% in 2012. Over the years, the player reduced the time at >85% of his HRmax and increased the time spent at 65-85% of his HRmax.

Variability in work intensity can be explained by the adaptations induced by training, which are confirmed by an increased anaerobic threshold. An increased anaerobic threshold allows the player to do the same work at a lower intensity. In addition, his experience leads him economize stress.

## 5. Conclusions

- Age is the main factor causing heart rate variability in team sports players since maximum heart rate decreases with age.
- Older players know how to economize stress, since they have a better understanding of the game.
- Using heart rate as an indicator of work intensity involves:
  + Determining the cardiovascular profile of each player.
  + Determining their real maximum heart rate.
  + Using relative values of percentage of work intensity with respect to their maximum heart rate.

Practical Implications:

- The maximum heart rate of each player should be annually examined by stress tests.
- Training loads can be adapted by using the percentage of maximum heart rate of each player.
- Training loads can be controlled according to the cardiovascular response of each player.

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## Statement of Competing Interests

The authors transfer the ownership of copyright to the journal American Journal of Sports Science and Medicine. They state that the article is original, has not been submitted for publication in other journals and has not yet been published either wholly or in part. They state that they are responsible for the research that they have designed and carried out; that they have participated in drafting and revising the manuscript submitted, whose contents they approve.

In the case of studies carried out on human beings, the authors confirm that the study was approved by the ethics committee and that the patients gave their informed consent.

They also state that the research reported in the paper was undertaken in compliance with the Helsinki Declaration and the International Principles governing research on animals.

They agree to inform in the form below of any conflict of interest that might arise, particularly any financial agreements they may have with pharmaceutical or biomedical firms whose products are pertinent to the subject matter dealt with in the manuscript.

## References

[1] Bangsbo, J., Mohr, M., Krustrup, P. "Physical and metabolic demands of training and match-play in the elite football player". J Sports Sci. 24 (7). 665-674. 2006.

[2] Buchheit, M., Lepretre, P.M., Behaegel, A.L., Millet, G.P., Cuvelier, G., Ahmaidi, S.L. "Cardiorespiratory responses during running and sport-specific exercises in hadball players". J Sci Med Sport. 12 (3). 399-405. 2009.

[3] Foster, C.D., Twist, C., Lamb, K.L., Nicholas, C.W. "Heart rate responses to small-sided games among elite junior rugby league players". J Strength Cond Res. 24 (4). 906-11. 2010.

[4] Alexiou, H., Coutts, A.J. "A comparison of methods used for quantifying internal training load in women soccer players". Int J Sports Psychiol Perform. 3 (3). 320-330. 2008.

[5] Borresen, J., Lambert, M.I. "Quantifying training load: A comparison of subjective and objective methods". Int. J Sports Psychiol Perform. 3 (1). 16-30. 2008.

[6] Coutts, A.J., Rampinini, E., Marcora, S.M., Castagna, C., Impellizzeri, F.M. "Heart rate and blood lactate correlates of perceived exertion during small-sided soccer games". J Sci Med Sport. 12 (1). 79-84. 2009.

[7] Álvarez, J., López, I., Echavarri, J.M., Quílez, J., Terreros, J.L., Manonelles, P. "Análisis científico de diferentes métodos de entrenamiento en el fútbol sala". Arch Med Deporte. 26. 93-103. 2009.

[8] Eston, R., Williams, J.G. "Reliability of rating of perceiver effort regulation of exercise intensity". Br J Sports Med. 22 (4). 153-155. 1998.

[9] Coutts, A.J., Rampinini, E., Marcora, S.M., Castagna, C., Impellizzeri, F.M. "Heart rate and blood lactate correlates of perceived exertion during small-sided soccer games". J Sci Med Sport. 12 (1). 79-84. 2009.

[10] Álvarez, J., Giménez, L., Corona, P., Manonelles, P. "Necesidades cardiovasculares y metabólicas del fútbol sala: análisis de la competición". Apunts. 67. 45-51. 2002.

[11] Jackson, A.S. "Estimación de la frecuencia cardiaca máxima de la edad. ¿Es una relación lineal?". Med Sci Sports Exerc. 39 (5). 822-829. 2007.

[12] Boudet, G., Garet, M., Bedu, M., Albuisson, E., Chamoux, A. "Median maximal heart rate calibration in different conditions: laboratory, field and competition". Int J Sports Med. 23 (4). 290-297. 2002.

[13] Álvarez, J., Corona, P., Giménez, L., Serrano, E., Manonelles, P. "Perfil cardiovascular en el fútbol-sala. Respuesta inmediata al esfuerzo". Arch Med Deporte. 83. 199-204. 2001.

[14] Álvarez, J., Corona, P., Giménez, L., Serrano, E., Manonelles, P. "Perfil cardiovascular en el fútbol-sala. Adaptaciones al esfuerzo". Arch Med Deporte. 82. 143-148. 2001.

[15] Beaver, W.L., Wassermann, K., Whipp, B.J. "A new method for detecting the anaerobic threshold by gas exchange". J Appl Physiol. 60. 2020-2027. 1986.

[16] Barbero-Alvarez, J.C., Soto, V.M., Barbero-Alvarez, V., Granda-Vera, J. "Match analysis and heart rate of futsal players during competition". J Sports Sci. 26 (1). 63-73. 2008.

[17] Castagna, C., D'Ottavio, S., Granda Vera, J., Barbero Alvarez, J.C. "Match demands of professional futsal: A case study". J Sci Med Sport. 12 (4). 490-494. 2009.

[18] Casamichana, D., Castellano, J., González, R. "Demanda fisiológica en juegos reducidos de fútbol con diferentes orientaciones del espacio". Int J Sports Sci. 2 (23). 141-154. 2011.

[19] O'Connor, P.J., Raglin, J.S., Morgan, W.P. "Psychometric correlates of perception during arm ergometry in males and females". Int J Sports Med. 17 (6). 462-466. 1996.

[20] Morganroth, J., Maron, B.J., Henry, W.L., Epstein, S.E. "Comparative left ventricular dimensions in trained athletes". Ann Intern Med. 82. 521-524. 1975.

[21] Álvarez, J., Giménez, L., Manonelles, P., Corona, P. "Importancia del VO2 máx. y de la capacidad de recuperación en los deportes de prestación mixta. Caso práctico: fútbol sala". Arch Med Deporte. 86. 577-583. 2001.

[22] Bouchard, C., Lortie, G. "Heredity and endurance performance". Sports Med. 1. 38-64. 1984.

[23] García, M., Leibar, X. Umbral Aeróbico y Umbral Anaeróbico. Entrenamiento de la resistencia de los corredores de medio fondo y fondo. Madrid, Gymnos, 1997.

[24] Lacour, J.R., Chatard, J.C. "Aspectos fisiológicos del fútbol". El entrenador Español de Fútbol. 5. 32-35. 1985.

[25] Parr, R.B., Wilmore, J.H., Bachman, D., Kerlan, R.K. "Professional basketball players. Atlethic profiles". Physician Sports Med. 6. 77-84. 1978.

[26] Wolford, S., Angove, M. "A comparison of training techniques and game intensities for national level netball players". Sports Coach. 14. 18-21. 1991.

[27] Barbero, J.C., Granda, J., Soto, V.M. "Análisis de la frecuencia cardiaca durante la competición en jugadores profesionales de fútbol sala". Apunts. 77. 71-78. 2004.

[28] Rubio, E., Rubio, A., Encarna, F. Estadística en ciencias sanitarias. Colección Monografías Didácticas nº 11. Universidad de Zaragoza. Capítulo 7, 2010.