

THE RELATIONSHIP BETWEEN HAND-GRIP STRENGTH, ANAEROBIC PERFORMANCE AND ISOKINETIC MUSCLE STRENGTH IN FEMALE HANDBALL PLAYERS

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ABSTRACT

The purpose of this study was to investigate the relationship between hand-grip strength, anaerobic power/capacity and isokinetic muscle strength in professional female handball players.

Nineteen female players volunteered to participate in this study (age: 19.68 ± 2.18 years; training age: 9.52 ± 2.03 years). Hand-grip strength and Wingate anaerobic power test were performed. Bilateral concentric isokinetic strength of the knee extensors/flexors was evaluated at 60, 150 and 240°/s.

There was a unilateral relationship ($p < 0.05$) between dominant hand-grip strength and isokinetic strength of right knee extension and flexion. There was a significant correlation between the 60°/s knee extension and flexion strength and absolute peak power and mean power ($p < 0.05$ and 0.01) but no measure of isokinetic knee strength was significantly correlated with relative variables and fatigue index ($p > 0.05$), except a significant correlation between the 60°/s right knee extension and relative peak power ($p < 0.05$).

In conclusion, hand-grip strength is correlated with isokinetic knee strength. However, there was lack of correlation between anaerobic performance and isokinetic knee strength evaluated at high angular velocity that could be explained by the different energetic pathways used during these tests.

Key words: Isokinetic strength, isometric strength, anaerobic power, anaerobic capacity, female athletes

KADIN HENTBOL OYUNCULARINDA EL KAVRAMA KUVVETİ, ANAEROBİK PERFORMANS VE İZOKİNETİK KAS KUVVETİ ARASINDAKİ İLİŞKİNİN İNCELENMESİ

ÖZET

Bu çalışmanın amacı profesyonel kadın hentbol oyuncularında el kavrama kuvveti, anaerobik güç/kapasite ve izokinetik kas kuvveti arasındaki ilişkinin incelenmesidir.

On dokuz kadın oyuncu çalışmaya gönüllü katılmıştır (yaş: $19,68 \pm 2,18$ yıl; antrenman yaşı: $9,52 \pm 2,03$ yıl). El kavrama kuvveti ve Wingate anaerobik güç testi uygulanmıştır. Diz ekstensör/fleksör bilateral konsentrik izokinetik kuvveti 60, 150 ve 240°/s açısız hızlarda değerlendirilmiştir.

Baskın el kavrama kuvveti ve sağ diz ekstensör ve fleksör izokinetik kuvveti arasında tek taraflı ilişki bulunmuştur ($p < 0,05$). 60°/s açısız hızdaki diz ekstensör ve fleksör kuvveti ile absolut zirve güç ve ortalama güç değerleri arasında önemli ilişki bulunmuştur ($p < 0,05$ ve $0,01$). Fakat 60°/s açısız hızdaki sağ diz ekstensör ile relatif zirve güç değerleri arasındaki önemli ilişki hariç, diğer tüm izokinetik diz kuvveti değerleri ile relatif değerler ve yorgunluk indeksi arasında ilişki bulunmamıştır ($p > 0,05$).

Sonuç olarak el kavrama kuvveti izokinetik diz kuvveti ile ilişkilidir. Ancak anaerobik performans ve yüksek açısız hızlarda değerlendirilen izokinetik diz kuvveti arasında ilişki bulunmamıştır ki bu durum bu testler sırasında kullanılan farklı enerji yolları ile açıklanabilir.

Anahtar kelimeler: izokinetik kuvvet, izometrik kuvvet, anaerobik güç, anaerobik kapasite, kadın sporcu

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INTRODUCTION

Handball is an Olympic sport which is played worldwide at a highly professional level in many European countries (Povoas et al., 2012). It is a very strenuous body-contact sport characterized by highly developed motor skills such as speed, explosive power, endurance, and strength (Saeterbakken et al., 2011). Nevertheless, scientific knowledge regarding elite team handball's working demands is limited (Povoas et al., 2012). Especially the number of studies dealing with physiological demands of female handball players is rather small in comparison to those for male athletes. The importance of women's handball in research literature has grown exponentially, with the most relevant articles published over the last decade (Povoas et al., 2012; Manchado et al., 2013; Lidor and Ziv, 2011; Koley et al., 2011; Zapartidis et al., 2009; Vargas et al., 2008)

The athlete's performance in high-level women's handball depends directly on diverse physiological attributes. To reach maximum player performance in handball, it is essential to use knowledge from various sports-related domains (Ziv and Lidor, 2009). Assessment of the physical capacities of athletes is one of the most important issues in modern sports; many tests are used during selection procedures, for screening candidates, or to monitor the efficacy of training regimes (Norkowski, 2002). Despite sports performance professionals and sports scientists focus on performance assessment, there are lacks of research examining the

relationships between various motor skills (Vescovi and McGuigan, 2008).

Hand-grip (HG) strength is important in handball as various movements rely on the continuous use of wrist and digits flexors in catching, holding, shooting and throwing the ball. Hand-grip strength is often used to evaluate muscular fitness, because typical hand dynamometers are simple, not expensive and well established in strength assessment of grip. In addition it has been demonstrated that HG correlates well with other measures of both maximal upper and lower body strength (Milliken et al., 2008; Cohen et al., 2010). At the same time muscular strength is one of the important factors in anaerobic performance. Anaerobic power can be defined as the ability of the athlete to transform the explosive power and energy of non-oxygen energy systems into power (Komi and Bosco, 1978). The Wingate anaerobic power test is a reliable and the most popular method for calculating the anaerobic peak power (PP) of lower limb muscles (Inbar et al., 1996). Strong correlations between measures of isokinetic strength and anaerobic power and capacity (PP and MP) have been shown in previous researches (Kin-İşler et al., 2008; Thorland et al., 1987; Çakır-Atabek et al., 2009; Alemdaroğlu, 2012). Furthermore, relationships between measures of isokinetic strength and hand-grip isometric strength have also been demonstrated (Holm et al., 2008; Hill et al., 1996). As indicated before, because of the lesser attention given to the female players, the purpose of the present study was to investigate the relationship between isometric hand-grip

strength, anaerobic peak power/capacity and isokinetic muscle strength in professional female handball players.

MATERIALS AND METHODS

Participants: Nineteen professional female handball players with mean (SD) age of 19.7 ± 2.2 years participated in this study. All subjects were members of the same team competing in the Turkish Super League who had trained for 2-3 hours per day, five days a week (training frequency: 2.53 ± 0.90 hours/day and 5.6 ± 1.0 days/week). Subjects' training experience was 6 - 13 years. Nine players played in the national team at different categories more than 5 times (6.89 ± 12.03). None of the participants had a remarkable clinical history. All subjects participated in the study voluntarily and written informed consent was obtained from each subject, who

was completely informed about the study. The study was conducted according to the Helsinki Declaration. All data was collected during the ovulation phase of the menstrual cycle.

Subjects' height was measured using a stadiometer (Holtain, Britain) and subjects' weight and percent body fat (%) were determined by bioelectrical impedance (BIA) analyzer (Tanita MC-180-MA, Japan). The BIA method was preferred due to its being easy, practical and reliable. The basic characteristics of the subjects are presented in Table 1. After 10-15 min of rest in sitting position systolic blood pressure (SBP), diastolic blood pressure (DBP) and resting heart rate (HR) were measured on the upper arm using sphygmomanometer (Microlife BP A100, Switzerland).

Table 1. Subjects' descriptive data

	Mean \pm SD
Age (years)	19.68 ± 2.19
Height (cm)	166.85 ± 5.47
Weight (kg)	63.17 ± 6.12
Percent Body Fat (%)	22.53 ± 3.76
Body Mass Index (kg/m^2)	22.75 ± 1.90
Resting SBP (mmHg)	111.95 ± 8.75
Resting DBP (mmHg)	68.47 ± 9.25
Resting HR (pulse/min)	71.21 ± 14.38
Training experience (years)	9.53 ± 2.04

SBP = Systolic blood pressure; DBP = Diastolic blood pressure; HR = Heart rate

Hand-grip isometric strength: Each subject was given a brief demonstration and verbal instructions for the hand-grip test using the Takei T.K.K.5101 digital hand-grip dynamometer (Takei Scientific Instruments Co. Ltd, Tokyo, Japan). If necessary the grip opening was adjusted according to the subject's hand size. The test was conducted only for the dominant hand, in standing, with

shoulder adducted and neutrally rotated and the wrist and the elbow in full extension. The dynamometer was held freely without support, not touching the subject's trunk (Koley et al., 2011). Three trials were allowed with sufficient recovery period and the highest score, recorded in kilograms, was saved as peak grip strength (kg). Limb dominance was determined by asking the subjects whether they were left- or right-handed.

Isokinetic testing: Bilateral concentric isokinetic strength of the knee extensors and flexors was measured using the CSMI-Humac/Norm™-770 model (Humac Norm Testing and Rehabilitation System, USA). Before each testing session, the dynamometer was calibrated in accordance with the manufacturer's recommendations. All subjects started with a standardized warm-up consisting of 10-min of cycling (Monark) at 55-60 rpm against no load, and 5-7 minute of stretching. Following the warm-up, subjects rested for 5-min. Knee extension and flexion were performed with the subjects in an upright seated position, with their hands gripping the sides of the dynamometer chair. Stabilizing straps were placed around the thorax, pelvis and the thigh. The resistance shin pad was placed at a level just above the medial malleolus. The subjects were positioned so that the axis of rotation of the lever arm of the device coincided with the line passing transversely through the femoral condyles.

Peak isokinetic concentric knee extension and flexion torque of both legs were evaluated at 3 angular velocities: 60, 150 and 240°/s. the knee extension and flexion contractions were performed through a range of 0 - 90° (full extension defined as 0°). Subjects were instructed to complete 3 submaximal trials at each angular velocity for familiarization and warm-up purpose. Subjects then performed 5 maximal repetitions of knee extension and flexion at each selected angular velocity. A 30-s time interval was provided between familiarization

and test session (Çakır-Atabek et al., 2009; Tsiokanos et al., 2002) whereas a 2-min rest period was given between each test velocity (Çakır-Atabek et al., 2009; Malliou et al., 2003). In addition, a break of at least 3-min was given when the machine setting was changed for the opposite leg (Daneshjoo et al., 2013). The order of testing was randomized for the dominant and non-dominant legs. Verbal encouragements and visual feedback were given by investigator to all subjects to help them concentrate on the quality of their movements. The greatest peak torque (Nm) for knee extension and flexion (out of the 5 trials in each velocity) was calculated automatically by the Humac®/2004 and served as the outcome measure.

The Wingate anaerobic test (WAnT): The WAnT was performed on a mechanically braked cycle ergometer (894 Ea, Peak Bike by Monark AB, Sweden). Subjects were seated on the ergometer and adjustments to the ergometer were made to ensure an optimal cycling position. Seat height was adjusted to each subject's satisfaction, and toe clips with straps were used to prevent the feet from slipping of the pedals. The WAnT was conducted according to widely accepted recommendations for standardization (Inbar et al., 1996). The WAnT was administered for 30-s and the resistance was set at 7.5% of body mass. The subjects were not allowed to stand up during the test and were encouraged to pedal as fast as they could prior to the application of resistance. Following application of resistance the subjects continued pedaling at maximum speed

throughout the remaining 30-s. Verbal encouragement was provided by the investigator. Absolute peak power (APP), relative peak power (RPP), absolute mean power (AMP), relative mean power (RMP) and minimum power were calculated automatically by the WAnT program via computer (Inbar et al., 1996) (Monark Exercise AB, Sweden) and were recorded for further analysis. A fatigue index (FI) was calculated by using the following equation (Inbar et al., 1996).

$$\text{Fatigue Index (FI)} = [(\text{Peak Power Output} - \text{Minimum Power Output}) / \text{Peak Power Output}] \times 100$$

RESULTS

Isokinetic knee strength, hand-grip isometric strength and anaerobic performance of female handball players are presented in Table 2 and 3, respectively. The correlation coefficients among measured variables are

Statistical analysis: All values were presented as mean \pm standard deviation. Before parametric analyses were done, the normality of distribution of the data was assessed with Kolmogorov–Smirnov test. Then, the relationship between hand-grip isometric strength, Wingate anaerobic test variables (APP, RPP, AMP, RMP, and FI) and isokinetic knee strength (twelve peak torque parameters) was evaluated using the Pearson Product Moment Correlation analysis. All analyses were executed in SPSS for Windows version 16.0 and statistical significance was set at $p \leq 0.05$.

presented in Table 4. Table 4 demonstrates a significant relationship between dominant hand grip strength and isokinetic strength of right, but not left, knee extension and flexion (in range of $r = 0.455$ and $r = 0.552$, $p \leq 0.05$ and $p < 0.01$).

Table 2. Isokinetic peak torque values of the subjects (mean \pm SD).

	Right knee extension	Right knee flexion	Left knee extension	Left knee flexion
60 ⁰ /s (Nm)	106.42 \pm 11.78	85.84 \pm 9.01	101.47 \pm 14.44	86.58 \pm 11.12
150 ⁰ /s (Nm)	87.42 \pm 9.83	71.84 \pm 12.14	83.58 \pm 10.58	74.32 \pm 10.30
240 ⁰ /s (Nm)	73.05 \pm 11.50	69.74 \pm 13.21	70.53 \pm 9.47	67.58 \pm 13.79

Table 3. The hand-grip strength, the peak power, mean power and fatigue index values of the subjects

	Mean \pm SD	Min - Max
Hand-grip (kg)	32.22 \pm 3.93	23.90 – 38.80
Load (kg)	4.74 \pm 0.46	3.90 – 5.70
Peak power (w)	628.09 \pm 91.12	439.46 – 801.04
Relative Peak power (w/kg)	9.93 \pm 0.90	8.45 – 11.88
Mean power (w)	360.65 \pm 46.78	251.04 – 465.52
Relative Mean power (w/kg)	5.71 \pm 0.45	4.83 – 6.56
Fatigue index (%)	83.21 \pm 10.96	58.09 – 98.48

For the absolute variables, there was a significant correlation between knee extension and flexion strength at 60⁰/s and the absolute PP and MP. On the

other hand, no measure of isokinetic knee strength was significantly correlated with the relative variables (PP and MP) or the fatigue index except a

significant correlation between the 60⁰/s right knee extension and relative peak power ($r = 0.536$, $p < 0.05$). In addition, the results of the present study showed

that the relationship between hand-grip strength and PP (w) and MP (w) was $r = 0.535$ ($p < 0.05$) and $r = 0.612$ ($p < 0.01$), respectively.

Table 4. Pearson moment correlation coefficient between different variables

	HG	Load	APP	RPP	AMP	RMP	FI
Right knee extension							
60 ⁰ /s (N.m)	0.455*	0.638**	0.751**	0.536*	0.700**	NS	NS
150 ⁰ /s (N.m)	0.489*	NS	NS	NS	0.482*	NS	NS
240 ⁰ /s (N.m)	NS	0.483*	NS	NS	0.551*	NS	NS
Right knee flexion							
60 ⁰ /s (N.m)	NS	0.647**	0.665**	NS	0.582**	NS	NS
150 ⁰ /s (N.m)	0.455*	NS	0.499*	NS	0.524*	NS	NS
240 ⁰ /s (N.m)	0.552*	0.719**	0.665**	NS	0.678**	NS	NS
Left knee extension							
60 ⁰ /s (N.m)	NS	0.585**	0.553*	NS	NS	NS	NS
150 ⁰ /s (N.m)	NS	0.614**	NS	NS	NS	NS	NS
240 ⁰ /s (N.m)	NS	0.561*	NS	NS	NS	NS	NS
Left knee flexion							
60 ⁰ /s (N.m)	NS	0.646**	0.530*	NS	0.546*	NS	NS
150 ⁰ /s (N.m)	NS	0.504*	NS	NS	0.592**	NS	NS
240 ⁰ /s (N.m)	NS	NS	NS	NS	NS	NS	NS

* $p \leq 0.05$

** $p < 0.01$

HG = Hand-grip; Load = load used during Wingate anaerobic power test; APP (w) = Absolute anaerobic peak power; RPP (w/kg) = Relative anaerobic peak power; AMP (w) = Absolute mean power; RMP (w/kg) = Relative mean power FI (%) = Fatigue index

DISCUSSION

The main finding of the present study is the existence of significant relation between anaerobic power and capacity and peak isokinetic concentric knee extension and flexion strength at a relatively low (60⁰/s) velocity. This finding is valid especially for the absolute but not for the relative variables. In addition, there was a significant relationship between dominant hand grip strength and isokinetic strength of right knee extension and flexion.

Several studies have dealt with the relationships between the results of the

WAnT and isokinetic tests. It has been reported that there was a significant relationship between isokinetic knee extension strength evaluated at 60 and 180⁰/s and absolute PP (Alemdaroğlu, 2012). Furthermore, Kin-Isler et al. (2008) reported that isokinetic concentric knee extension strength was significantly correlated with anaerobic PP and MP at all contraction velocities evaluated at 60, 150 and 240⁰/s. However, the PP was significantly correlated only with the isokinetic knee flexion strength at 240⁰/s (Kin-Isler et al., 2008). In another study it has been shown that there was a moderate to high correlation between absolute and

relative anaerobic PP and isokinetic concentric knee strength (Çakır-Atabek et al., 2009).

The aforementioned studies above were conducted with male subjects and the results are consistent with the findings of the current study which indicate a significant correlation between the knee extension and flexion strength at 60°/s and absolute PP and MP in female handball players. On the other hand, the results are in contrast with the findings of the current study which demonstrated that the absolute PP was not significantly correlated with intermediate and high isokinetic strength. In another study it was demonstrated that there was a strong correlation between isokinetic knee extension (measured at 30–300 °/s) strength and anaerobic power (PP) and capacity (MP) of female sprinter and middle distance runners (Thorland et al., 1987). These conflicting results may be caused by a number of factors, such as training experience, level of play, age and gender (Daneshjoo et al., 2013). Gender-related factors include anatomy, hormonal profile, ligament laxity, and the effect of menstrual cycles on the knee strength. Typically women have a laxity of the ligaments around the knee joint (de Loes et al., 2000; Dugan, 2005) which may impact upon knee strength. Another possible reason for the lack of correlation between WAnT test performance and isokinetic strength evaluated at high angular velocity may be the different energy systems that each measure needs. Individual isokinetic contractions do not last more than 5 seconds. Therefore the phosphagen system (ATP-PC)

contribute to the energy demand. On the other hand in the Wingate test, the glycolytic system is dominant in terms of energy production. Different energetic pathways used during the test could explain the lack of association between these measures (Kin-Isler et al., 2008).

It is important to note that to succeed in specific sport activities, it is often necessary to have certain motor skills. For ball games in which it is essential to use one's hands, hand-grip strength may play a key role for performance. The results of the present study demonstrated that there was significant relationship between dominant hand-grip strength and the isokinetic strength of the right knee extensors and flexors. Eighty percent of the subjects were right-handed and this case may explain why there was not a significant relationship between dominant hand-grip strength and isokinetic strength of left knee extension and flexion. Similarly Holm et al. (2008) demonstrated that the relationship between hand-grip strength and isokinetic quadriceps strength was high ($r = 0.84$ and 0.85), for 60 and 240 °/s, respectively. Hill et al. (1996) showed that isometric hand-grip strength could predict low velocity isokinetic strength fairly well, but had poor predictive ability for faster velocities. The results of the present study showed that the relationship between hand-grip strength and PP (w) and MP (w) was $r = 0.535$ ($p < 0.05$) and $r = 0.612$ ($p < 0.01$), respectively. These results are consistent with the result of previous studies which demonstrated that HG correlates well with other measures of both maximal upper and lower body strength (Milliken et al.,

2008; Cohen et al., 2010) or total muscle strength ($r = 0.736$ and 0.890) (Wind et al., 2010).

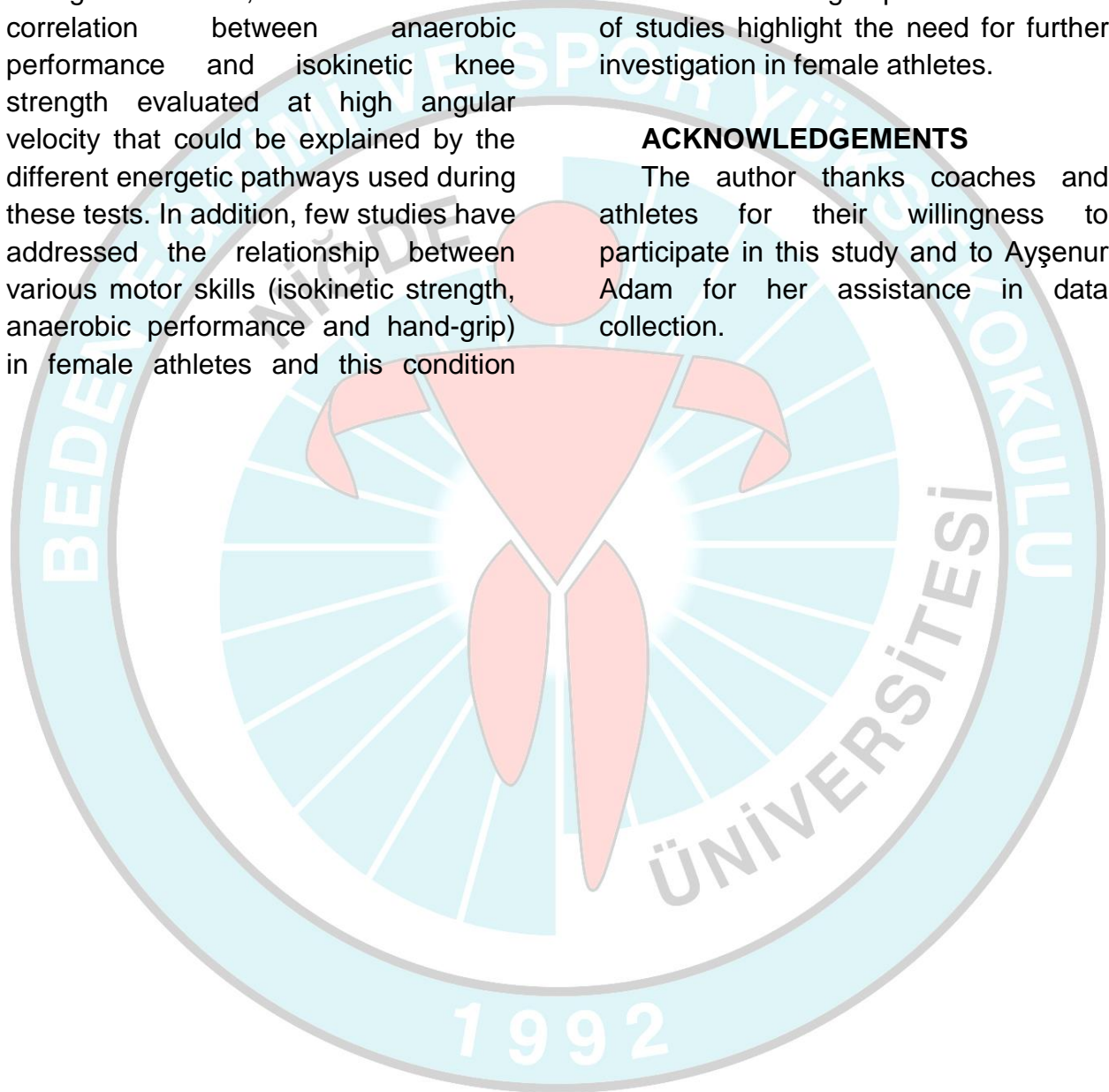
CONCLUSION

In conclusion, hand-grip strength was correlated with isokinetic knee strength. However, there was lack of correlation between anaerobic performance and isokinetic knee strength evaluated at high angular velocity that could be explained by the different energetic pathways used during these tests. In addition, few studies have addressed the relationship between various motor skills (isokinetic strength, anaerobic performance and hand-grip) in female athletes and this condition

restricts our discussion. Additionally the sample size of this study was limited ($n=19$) since the handball team included only 19 members on its roster. Furthermore, the findings of this research is qualified for the small population of female handball players with similar training experience and lack of studies highlight the need for further investigation in female athletes.

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