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Intra-rater and intraday test-retest reliability for physical performance tests in young Chilean tennis players

Confiabilidad test-retest intraevaluador e intradía para pruebas de rendimiento físico en jóvenes tenistas chilenos

Pablo Luna-Villouta[1], Ivana Leao Ribeiro[2], César Faúndez-Casanova[3], Jaime Vásquez-Gómez[4], Carol Flores-Rivera[5], Rodrigo Vargas Vitoria[3*]

[1] Facultad de Educación. Pedagogía en Educación Física. Universidad San Sebastián, Chile

[2] Departamento de Kinesiología. Facultad de Ciencias de la Salud. Universidad Católica del Maule, Chile

[3] Facultad de Educación. Pedagogía en Educación Física. Universidad Católica del Maule, Chile

[4] Centro de Investigación de Estudios Avanzados del Maule (CIEAM). Universidad Católica del Maule, Chile

[5] Facultad de Educación y Ciencias Sociales. Universidad Andrés Bello, Chile

* **Correspondence:** Rodrigo Vargas Vitoria, rvargas@ucm.cl

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Abstract

In tennis, the use of standardized tests seeks to provide a useful complement tool for performance monitoring, becoming a very valuable instrument for evaluating the athlete's physical condition. The aim of the study was to assess the intra-rater and intra-day test and retest reliability for physical performance in young Chilean tennis players. The sample size was of 86 young tennis players (15.4 ± 0.8 years old), male = 58; female = 28. Variables of physical performance were tested, 20 m. sprint test; modified agility test (MAT test); sit-and-reach test and shoulder flexibility; hand grip strength (HGS); horizontal jump (HJ), medicine ball throw (MBT), countermovement Jump (CMJ) and Abalakov (ABK). To examine the intra-rater and intra-day test-retest reliability, subjects performed the tests twice on the same day. Results showed excellent test-retest values of relative reliability (intraclass correlation coefficients; *ICC* between .80 - 1.00), respect to the absolute reliability, all the tests presented small values of standard error of measurements (*SEM*) and adequate values for the minimal detectable change (*MDC*). Physical performance tests used in this study reported high intra-rater and intraday test-retest reliability for all male and female individuals, except for agility in men, which shows moderate relative reliability.

Keywords: tennis, reliability, physical fitness, field tests, young boys.

Resumen

En tenis, el uso de pruebas estandarizadas busca brindar un complemento útil para monitorear el rendimiento, convirtiéndose en un instrumento muy valioso para evaluar la condición física del deportista. El objetivo del estudio fue evaluar la confiabilidad test-retest intraevaluador e intradía para pruebas de rendimiento físico en jóvenes tenistas chilenos. La muestra fue de 86 tenistas juveniles (15.4 ± 0.8 años), varones = 58; damas = 28. Se probaron las variables de rendimiento físico, sprint de 20 m; test de agilidad modificado (MAT test); test sit-and-reach y flexibilidad de hombros; fuerza prensión manual (HGS); salto horizontal (HJ), lanzamiento de balón medicinal (MBT), salto con contramovimiento (CMJ) y Abalakov (ABK). Para examinar la confiabilidad test-retest intraevaluador e intradía, los sujetos realizaron las pruebas dos veces el mismo día. Los resultados muestran excelentes valores test-retest de confiabilidad relativa (coeficiente de correlación intraclase; *ICC* entre .80-1.00), respecto a la confiabilidad absoluta, se presentaron valores pequeños de error estándar de medición (*SEM*) y valores adecuados para la mínima diferencia detectable (*MDC*). Las pruebas de rendimiento físico utilizadas reportan una alta confiabilidad intraevaluador e intradiaria test-retest para el total de la muestra y por sexo, excepto la agilidad en hombres, con una confiabilidad relativa moderada.

Palabras clave: tenis, confiabilidad, aptitud física, pruebas de campo, jóvenes.

Introduction

Tennis is a sport discipline that has proved a growing number of players, which reaches up to approximately 75 million people worldwide (Barber-Westin et al., 2010). It is a kind of sporting event that gives way to a large number of tournaments in different categories. Also, best tennis players have become sports icons and role models for generations. This is why tennis attracts a large amount of young people to practice it. This is also a source of motivation to reach the highest competitive level possible (Fernandez, 2006).

Tennis performance depends on several factors including morphological, technical and physical aspects, such as speed, flexibility, muscular strength and muscle power (Girard & Millet, 2009; Villouta et al., 2019). Evidence supports the argument that functional capacities are necessary to compete on higher levels (Myburgh et al., 2016). For example, high jump, maximum strength from the dominant limb and agility have been regarded as good predictors of tennis performance (Myburgh et al., 2016).

The use of standardized tests seeks to provide a useful complement to subjective training evaluations, becoming an attempt to evaluate the strengths and weaknesses of a certain player (Girard & Millet, 2009). Besides, they are valuable tools both for the selection of the suitable sport type for a subject according to their anatomical qualities and to control the training and competition programs (Pradas de la Fuente et al., 2013; Torres et al., 2006).

Therefore, it has become apparent that simple and easily accessible tests are needed. They should be carried out near the training centers and that should be related to the physical performance for a specific sport type in order to check the effect of training and competition has on the athlete (Alricsson et al., 2001).

Usefulness of the physical performance tests depends on their reliability, that is, the tests must be consistent and error free (Portney & Watkins, 2009). Thus, there is concern in conducting more reliable and valid physical performance tests (Alricsson et al., 2001). Physical performance tests have been reported in literature to show acceptable reliability indices (Burnstein et al., 2011). However, it is important to point out that test effectiveness also depends on the experience of the evaluator. Therefore, it is important to consider relative reliability data, through the intraclass correlation coefficients and absolute reliability, standard error of measurements, minimal detectable change and Bland-Almn with 95% limits of agreement. These data are important to identify the reliability of the evaluator's measurements and also contribute to evaluate the effectiveness of intervention programs in the sports environment, using highly reliable results (Bruton et al., 2000).

Thus, it is suggested that there is a reduced number of physical performance tests, especially tests applied in the field, that have demonstrated its reliability (Eriksson et al., 2015), even more, considering the use of low-cost instruments, (Eriksson et al., 2015; Vicente-Rodríguez et al., 2011), such as manual stopwatches or tape measures among others. When it comes to tennis, some studies have reported the reliability of physical performance tests in tennis (Sekulic et al., 2017; Stewart et al., 2014). These results show the need to have more evidence about the reliability of this type of measurement.

Having considered all this background, the objective of this study was to evaluate the intra-rater and intra-day test-retest reliability when testing physical performance in young Chilean tennis players.

Materials and Methods

Participants

This study is observational and cross-sectional, with analytical and reliability characteristics, which is based on the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (von Elm et al., 2014). The sample of this investigation corresponds to 86 young tennis players of both sexes (average age 15.4 ± 0.8 years old), divided into: male (n = 58) and female (n = 28), who attend tennis clubs in Chile. These clubs had taken part of national and/or international tournaments and had been certified by the Chilean Tennis Federation (FETECH) or the International Tennis Federation (ITF). The participants were selected by means of a non-probabilistic convenience sampling. The inclusion criteria were the following: 1) Competitive Chilean tennis players between 14 and 16 years old; 2) systematic training, consisting of a weekly minimum of 10 hours for at least the last 12 months; 3) Having participated in international tournaments in the last two years. On the other hand, the exclusion criteria were: 1) Failure to complete all the evaluations; 2) Failure to appear with appropriate clothing or sports sneakers for physical evaluations; 3) Having a physical injury that might prevent maximum performance of affects the result of the evaluations.

When it comes to the procedure, a letter of consent was sent to the directors of the tennis clubs, stating the purpose of the investigation, and inviting them to participate. Letters of consent forms were also sent to the subject's parents, informing about the objective of the study, the anonymous and voluntary nature of testing, and the characteristics of evaluations. After approval and signing, subjects' participation in the evaluations was confirmed. The ethics committee from the Universidad San Sebastián, Chile also approved the study project (Res. N° 51- 2018 - 20).

Instruments

Anthropometry. Body weight (kg) was measured using a mechanical scale (Seca 700, Hamburg, Germany), with a precision of 50 grams, ranging from 0 to 220 kg Height (cm) was measured according to the Frankfurt plane without shoes, using an aluminum stadiometer of Seca 220 brand (Hamburg, Germany), graduated in millimeters; its scale was (0.60 – 2.20 mm). For skin folds (triceps brachial and medial leg), measurement was done with a Harpenden Skinfold® (Baty International Ltd, West Sussex, UK) anthropometric forceps.

Sprint 20 m. It was carried out according to the protocol described by Martínez López (2011). The participant had to be in a high starting position behind the starting line, and, at the signal, would travel the distance in the shortest time possible. Measurements were recorded using a digital stopwatch (Casio Hs -70w -1DF).

Modified agility test (MAT test). This test involves moving and changing direction over a total distance of 20 m at maximum speed. For this test, four cones were arranged in the shape of a "T", the subject sprinted in a straight line to the first cone placed at 5 m, and then to a second cone placed 2.5 m to his left. This was done by moving laterally without crossing the feet. The subject then moves in the same manner to the right side to reach the third cone, placed at 5 m. They then return to the middle cone and finish at the starting position. The drill was considered to have been completed correctly when the base of the cone was touched. Was carried out as indicated by Sasi et al. (2009). Measurements were recorded using a digital stopwatch (Casio Hs - 70w - 1DF).

Sit-and-reach test. It was carried out following the recommendations made by Vanhelst et al. (2016). At the beginning of the execution, the subject was sitting on the ground, barefoot, with his legs together and extended. Your feet should be close to the measuring box, with your hands and arms extended and together forward. At the signal, the athlete flexed the trunk forward, pushing with both hands, and the maximum distance was recorded. The value 0 (zero) was located at the height of the feet under the drawer.

Shoulder flexibility. It was carried out following the recommendations by Martínez López (2011). At the beginning of the test, the subject stood with the trunk straight and with the legs together and extended. With both hands he grasped a millimeter stick, placed horizontally in front of the body and with his arms outstretched. At the signal, he must have slowly raised the stick over his head and behind his back. The distance between the thumbs of each hand was measured.

Hand grip strength (HGS). It was carried out according to the protocol described by España-Romero et al. (2010). Dominant handgrip strength test was performed in a standing position, with the elbow extended, and the arm positioned with the dynamometer parallel to the subject's side. Participants were asked to perform a maximal voluntary contraction, squeezing the dynamometer as hard as possible, for 3 s. Was measured with a Jamar Sammons Preston manual hydraulic dynamometer (kg).

Medicine ball throw (MBT). It was carried out according to the protocol described by Martínez López (2011). Holding a 3 kg medicine ball, the players stood at a line facing the throwing direction with the feet side-by-side and slightly apart. After the ball was brought back behind their head with two hands, it was thrown forward as far as possible without moving the feet or cross the line, to perform overhead MBT. To measure the results, a Stanley Power Lock millimeter tape was used.

Horizontal jump (HJ). The athlete stood behind a line marked on the ground with feet slightly apart. A two-foot takeoff and landing task was used, with arm swing and knee flexion to provide forward momentum. Subject attempted to jump as far as possible, landing on both feet without falling backward, following the protocol by Vanhelst et al. (2016). To measure the results, a Stanley Power Lock millimeter tape was used.

Countermovement jump (CMJ). The subjects performed the jumps starting in a standing position with their hands on their hips; then, they flexed their knees using a self-selected depth and jumped as high as possible. Were performed with the Globus Ergo Jump platform (Bosco System), according to the recommendations proposed by Bosco and Padulles (1994).

Abalakov test (ABK). The subjects performed the jumps starting in a standing position with their hands and their arms free; then, they flexed their knees using a self-selected depth and jumped as high as possible, with the movement of their arms, following the protocol made by Bosco and Padulles (1994). Were performed with the Globus Ergo Jump platform (Bosco System),

Procedures

The anthropometric evaluations were performed in the morning, before any type of physical activity, in a specially equipped room, which allowed for individual and private measurements. Those that were performed by a trained evaluator following the standard procedures from Ross and Marfell-Jones (1991) (Norton et al., 1996). Percent Body fat was calculated with regression equations proposed by Slaughter et al. (1988).

The physical performance tests were carried out in the morning period, after the anthropometric ones, on tennis courts, on a clay surface. Those evaluated had to wear shorts, athletic shirt, and sports shoes, to match competition clothing. Two experienced evaluators (holding Masters in Sports Sciences, MSc.) were in charge of the evaluations. These evaluators had the necessary experience of 8 to 10 years collecting information, and they were experienced on taking the tests, through theoretical learning and through practice by carrying out pilot tests in 28 9 to 12-year-old subjects who played tennis on a regular basis. Tests were performed according to the following protocol: first, a 15-minute warm-up was carried out, with general physical exercises and stretching. Breaks between each test were 5 minutes.

The application sequence was: First the speed test (20 m sprint) that were executed following the recommendations by Martínez López (2011), secondly, the agility test, MAT test (Modified Agility Test) was carried out as indicated by Sasi et al. (2009). Third, the flexibility evaluation was performed, for the Sit and reach; Fourth is the Shoulder flexibility test, both test were executed twice for each subject following the recommendations by Martínez López (2011). Fifth, the Muscular Strength evaluations were carried out, hand grip strength (HGS). Sixth, the horizontal jump was performed with feet together and in seventh place, the medicine ball thrown with both hands over the. Finally Vertical Jumps were executed, first the Countermovement Jump Test (CMJ) and then the Abalakov (ABK), according to the recommendations made by Bosco and Padulles (1994).

Statistical Analysis

Statistical analysis was carried out using the IBM SPSS® Statistics version 17.0 and with Microsoft Excel® 2016 spreadsheets. Mean, standard deviation (*SD*) and confidence interval (*CI* 95%) were considered. The Kolmogorov-Smirnov test was used to determine the normal distribution of the variables. Relative intra-rater intra-day reliability in physical performance test was calculated using the randomized intraclass correlation coefficients model ($ICC_{2,1}$; "trial - to trial within day"). For all analyzes, *ICC* values were classified as follows: poor when below .20; just from .21 to .40; moderate from .41 to .60; good from .61 to .80 and very good .81 to 1.00. The standard error of measurements (*SEM*) and the minimal detectable change (*MDC*); with a confidence interval of 95%, were calculated for the absolute reliability considering mathematical equations, as follows:

$$SEM = SD\sqrt{1 - ICC}$$

$$MDC = SEM * 1.64 * \sqrt{2}$$

Where: *SEM*, standard error of measurements. *SD*, standard deviation. *MDC*, minimal detectable change.

Finally, Bland-Altman graphs were made to visualize the difference against the average values of both the test and retest of physical performance tests, using a central continuous line in the images, which represents the average differences (systematic error), with dashed lines representing the upper and lower limits of 95%.

Results

Table 1 shows the characterization of the sample, the mean values, standard deviation (*SD*) and 95% confidence interval

(*CI* 95%) are presented, both for the total sample (n = 86), as well as for male (n = 58) and female (n = 28), respectively.

Table 1. Descriptive characterization of the Sample

Variables	Total (N = 86)				Male (N = 58)				Female (N = 28)			
	Mean	*SD*	*CI* 95%		Mean	*SD*	*CI* 95%		Mean	*SD*	*CI* 95%	
			LL	*UL*			*LL*	*UL*			*LL*	*UL*
Age (years)	15.4	0.8	15.3	15.6	15.4	0.8	15.2	15.6	15.3	0.8	15.0	15.6
Height (m)	171.2	7.9	169.6	173.0	174.2	7.6	172.0	176.1	164.9	3.7	163.5	166.3
Weight (kg)	59.7	10.1	57.6	61.9	64.3	7.9	62.2	66.4	50.1	6.9	47.6	52.8
∑ 2 skinfolds (mm)	21.6	6.3	20.4	22.9	21.1	5.6	19.7	22.6	22.8	7.5	20.2	25.5
FM (kg)	10.3	3.3	9.7	11.1	10.7	3.4	9.8	11.6	9.7	3.2	8.6	10.9
FFM (kg)	49.5	8.6	47.6	51.3	53.7	6.6	51.9	55.3	40.8	5.2	39.0	42.8
PBF (%)	17.3	4.4	16.4	18.2	16.5	4.1	15.5	17.6	19.0	4.6	17.4	20.7
Days training/week	4.6	0.8	4.5	4.8	4.6	0.8	4.3	4.8	4.8	0.7	4.5	5.0
Hours training/week	14.4	4.4	13.5	15.4	15.0	4.5	13.8	16.1	13.1	4.0	11.6	14.8

Note: *SD*- Standard deviation; *CI* - Confidence Interval; *LL* - Lower limit; UL - Upper Limit; ∑ 2 skinfolds – summation Triceps-Leg Medial skinfolds; FM – Fat Mass; FFM– Fat Free Mass; PBF – Percent Body Fat

In Table 2, the value obtained in test and retest for physical performance is shown, where no changes are observed for 20 m Speed and Agility, while the other tests shown small variations.

Table 2. Descriptive statistics test-retest

Variables		Total (N = 86)				Male (N = 58)				Female (N = 28)			
		Mean	*SD*	*CI* 95% *LL*	*CI* 95% *UL*	Mean	*SD*	*CI* 95% *LL*	*CI* 95% *UL*	Mean	*SD*	*CI* 95% *LL*	*CI* 95% *UL*
HJ (cm)	test	181.5	11.2	179.3	183.9	185.5	10.5	182.9	188.5	173.4	7.4	170.6	176.3
	retest	180.8	10.9	178.6	183.1	184.8	10.1	182.3	187.6	172.5	7.5	170.0	175.4
CMJ (cm)	test	24.2	4.4	23.2	25.1	25.8	3.8	24.7	26.6	20.8	3.6	19.5	22.0
	retest	24.0	4.4	23.1	25.0	25.7	3.8	24.7	26.6	20.6	3.6	19.2	21.9
ABK (cm)	test	30.9	4.9	29.9	31.9	32.7	4.2	31.6	33.7	27.3	41	25.7	28.7
	retest	30.7	4.9	29.7	31.8	32.5	4.2	31.4	33.5	27.1	4.1	25.4	28.5
HGS (kg)	test	36.0	8.1	34.1	37.6	39.4	7.0	37.5	41.2	28.9	5.1	27.1	30.8
	retest	35.5	8.1	33.7	37.1	38.9	7.1	37.2	40.7	28.4	4.9	26.6	30.2
MBT (m)	test	7.0	1.5	6.7	7.3	7.7	1.3	7.3	8.0	5.7	1.0	5.3	6.0
	retest	6.9	1.5	6.6	7.3	7.6	1.3	7.2	7.9	5.7	1.0	5.3	6.0
Speed 20 m (s)	test	4.0	0.3	3.9	4.0	3.9	0.3	3.8	4.0	4.1	0.3	4.0	4.2
	retest	4.0	0.3	3.9	4.1	3.9	0.3	3.8	4.0	4.2	0.3	4.1	4.2
Agility (s)	test	7.2	0.5	7.1	7.3	7.2	0.6	7.0	7.3	7.3	0.3	7.2	7.4
	retest	7.2	0.7	7.0	7.3	7.1	0.8	6.9	7.3	7.3	0.3	7.2	7.5
Sit and Reach (cm)	test	12.2	10.0	10.2	14.2	9.1	10.2	6.5	11.8	18.6	5.8	16.4	20.7
	retest	11.9	9.6	9.9	13.7	8.8	9.7	6.4	11.4	18.1	5.9	15.8	20.0
Shoulder Flexibility (cm)	test	94.4	8.3	92.6	95.9	97.8	5.6	96.4	99.2	87.4	8.6	84.3	90.3
	retest	94.9	8.0	93.2	96.4	98.3	5.2	97.0	99.6	88.0	8.5	84.9	91.0

Note: *SD*- Standard deviation; *CI* - Confidence Interval; *LL* - Lower limit; UL - Upper Limit; HJ – Horizontal Jump; CMJ- Vertical Jump Countermovement; ABK –Abalakov Jump; HGS – Handgrip Strength; MBT – Medicine ball throw

Table 3. Intra-day intra-rater reliability, relative and absolute evidence of physical tests

Variables	*ICC*			*CI* 95%						*SEM*			*MDC*	
				LL	*UL*	*LL*	*UL*	*LL*	*UL*					
	Total	Male	Female	Total		Male		Female		Total	Male	Female	Total	Male
HJ (cm)	.99	.99	.99	.99	1.00	.98	.99	.98	1.00	0.93	1.06	0.74	2.10	2.34
CMJ (cm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.14	0.20	0.12	0.33	0.43
ABK (cm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.15	0.19	0.11	0.36	0.43
HGS (kg)	1.00	1.00	1.00	1.00	1.00	.99	1.00	.99	1.00	0.37	0.41	0.29	0.85	0.95
MBT (m)	1.00	1.00	1.00	1.00	1.00	.99	1.00	1.00	1.00	0.07	0.09	0.03	0.16	0.20
Speed 20 m (s)	.99	.98	.97	.98	.99	.97	.99	.93	.98	0.46	0.64	0.05	1.08	1.49
Agility (s)	.80	.77	.99	.70	.87	.62	.87	.99	1.00	0.30	0.37	0.03	0.70	0.85
Sit and Reach (cm)	1.00	1.00	.99	1.00	1.00	.99	1.00	.99	1.00	0.55	0.55	0.41	1.23	1.22
Shoulder Flexibility	1.00	.99	1.00	1.00	1.00	.99	1.00	1.00	1.00	0.46	0.50	0.38	1.03	1.09

Note: *ICC* – Intraclass Correlation Coefficients; *CI* – Confidence Interval; *LL*- Lower limit; *UL* - Upper Limit; *SEM* – Standard Error of Measurements; *MDC*–Minimal Detectable Change; HJ – Horizontal jump; CMJ- Vertical Jump Countermovement; ABK –Abalakov Jump; HGS – Handgrip Strength; MBT – Medicine ball throw.

In Table 3, for the total sample, in all physical performance tests, excellent test-retest analyzes are reported on the same day, the *ICC* fluctuated between .80 to 1.00, the lowest value for relative reliability is in Agility (*ICC* = .80; *CI* 95% = .70 - .87), and the highest values are obtained in CMJ, ABK, HGS, MBT, Sit and Reach and Shoulder Flexibility (*ICC* = 1.00; *CI* 95% = 1.00 - 1.00). About the absolute reliability, the *SEM* presented small values. In detail, they fluctuated from 0.14 to 0.93 cm for the Jump Tests, for HGS it was 0.37 kg, for MBT it was 0.07 m, for the Flexibility test it ranged from 0.46 to 0.55 cm, for 20 m Speed and Agility it varied from 0.46 to 0.30 s respectively, while the *MDC* presents adequate values. In the jumping tests it was 0.33 to 2.10 cm, HGS 0.85 kg, MBT 0.16 m, on the flexibility tests varied from 1.02 to 1.23 cm, for the 20 m Speed 1.08 s and for Agility 0.70 s. Both *SEM* and *MDC*, are higher for males compared to females, in all tests. For the case of men, the lowest results were in Agility (*ICC* = .77; *CI* 95% = .62 - .87) and the highest was in CMJ and ABK (*ICC* = 1.00; *CI* 95% = 1.00 - 1.00); finally, the women showed lowest values in 20 m Speed (*ICC* = .97; *CI* 95% = .93-.98) and were best in CMJ, ABK, MBT and Shoulder Flexibility (*ICC* = 1.00; *CI* 95% = 1.00 - 1.00). Furthermore, the Bland-Altman graphs (Figure 1) showed that the test-retest measurements have an average difference close to zero in all tests.

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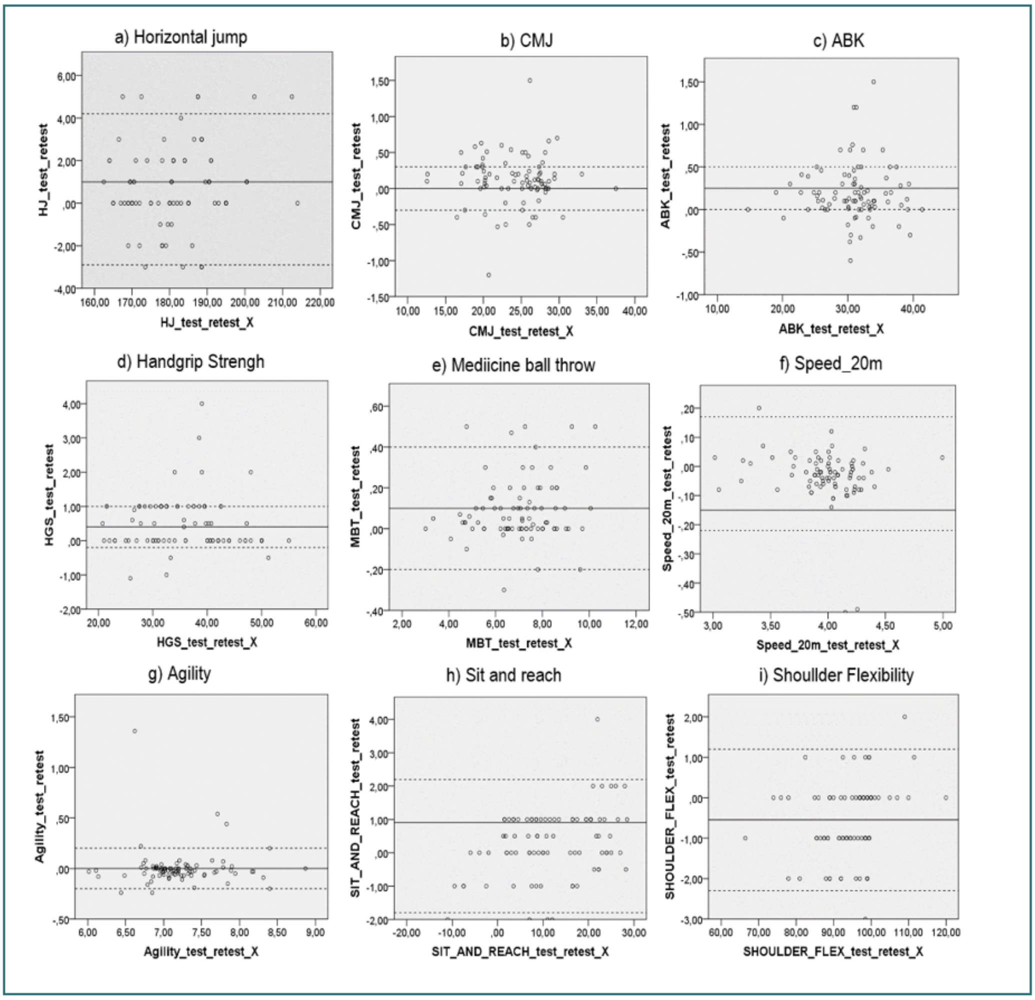
Figure 1. Bland-Altman graphs that show the differences with the average values of the test-retest (n = 86)



Note: The central continuous line represents the average differences (systematic error). The dotted lines represent the upper and lower limits of 95%.

Discussion

The objective of this study was to evaluate intra-rater and intra-day test-retest reliability for physical performance tests in young Chilean tennis players. Results obtained, both in relative (*ICC*) and absolute (*SEM* and *MDC*) reliability, showed that the field tests to evaluate physical performance are highly reliable when carried out on the same day. The *ICC* of this study, in the total sample fluctuated between .80 and 1.00, a result very similar to other studies consulted with young athletes and tennis players (Vicente-Rodríguez et al., 2011), the above was achieved using low-cost elements such as manual digital chronometer, tape measure and jumping platforms.

The aforementioned was reinforced by the Bland-Altman analysis where all physical fitness tests showed an average difference of near zero, these findings are consistent with those found in similar studies on other sports groups (Stewart et al., 2014). This highlights that these tests can become a serious contribution to the planning of training, competition, and injury prevention, providing reliable ad valid data capable of identifying changes in physical performance.

In this way, these highly reliable results might be due, on the one hand, to the experience and theoretical/practical training of the evaluators, as well as to the fact that the subjects evaluated were tennis players accustomed to this kind of movement patterns due the development of their sport and training (Eriksson et al., 2015; Sekulic et al., 2017), another advantage observed from these results, can be used in future experimental studies, to consider changes, even minor ones, in the performance tests. These assumptions are relevant at practical level, knowing these values can identify effects of a training or injury prevention, especially for tennis player in the same age range similar to the present study.

The Horizontal Jump and Vertical Jumps (CMJ and ABK), showed excellent levels of absolute and relative reliability, these results are consistent with those reported by other studies (Fernández-Santos et al., 2015; Vanhelst et al., 2016), thus, these jumping test are a reliable measure for assessing the strength of young tennis players' lower limbs.

In the flexibility tests, Sit and Reach and Shoulder Flexibility, same as in another study (Henriques#Neto et al., 2020), which included athlete from different disciplines, reliability values were high, although higher in our study, confirming that this type of evaluations have a very good

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reliability in different sports or physically active populations (Pion et al., 2015), which is very important for injury prevention, since the lack of flexibility is associated with decreased physical performance and increased pain and/or injury (Aben et al., 2018; Oosterhoff et al., 2019).

HGS and MBT Tests evidenced an excellent reliability. These results were similar to those found in other studies on teenage (Vanhelst et al., 2016) and college athletes (Kovacs et al., 2007). The use of this type of test is very important in determining the level of strength of upper limbs, which are not fundamental for sports performance, especially in tennis strikes, and to detect weaknesses, due to the high volume of use of the upper body segments in training and matches of this sporting discipline (Fernández-García et al., 2019; Fett et al., 2017; Kovalchik & Reid, 2017).

The 20 m Speed test delivered high reliability values, which is consistent with that reported in other studies (Sekulic et al., 2017; Vanhelst et al., 2016), this confirms that this test, which has been traditionally used in the sport, it is reliable and valid for evaluating speed in young athletes.

In regard to the agility test, this was the one that showed the lowest values of relative reliability in the total sample (*ICC* = .80; *CI* 95% = .70 - .87) and especially in men (*ICC* = .77; *CI* 95% = .62 - .87). These results were lower than those obtained in other studies: who applied the test to a population of young tennis players (Sekulic et al., 2017), or they evaluated young people who practiced sports other than tennis (Stewart et al., 2014) or used the same test on young soccer players (Sporis et al., 2010).

In these cases, the differences can be attributed to these subjects being older, so their level of experience could be wider on this type of test. besides, measuring instruments were not the same, thus contributing to a substantial difference in accuracy. These aspects have been described as elements that hinder standardizing a protocol and consequently, a uniform application across the population of young athletes (Henriques#Neto et al., 2020).

This study presents some limitations, such as, the non-probabilistic selection and quantity of sample tested, which limits the generalization of the results in other athletes. In addition, young players evaluated were quite homogeneous in age, sports background, and level of competition, which limited the scope of the study. Nevertheless, the main strength of the study is the novelty of the subject, which is rarely explored in South America. This study also sheds some light on procedures and tests, which are simple and quick to carry out, demanding minimal equipment and physical space and they can also be easily replicated.

Conclusions

In general, the physical performance tests evaluated and applied in this study reported high relative intra-day and intra-rater reliability, for all males and females, except for agility in men, showing a moderate relative reliability. The study, in turn, shows a very good absolute reliability with very low *SEM* values, in the total sample and by sex. Therefore, the physical performance tests evaluated in thus study and applied by trained personnel with previous experience proved to be reliable tests to monitor training, competition, and the risk of injury in young tennis players. For these reasons, results of this study might have implications for strengthening the process of sports training of young tennis players in the short, medium, and long-term training programs.

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