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ORIGINAL

REPRODUCTIBILIDAD DEL INSTRUMENTO HC

THE HC INSTRUMENT REPRODUCIBILITY

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ABSTRACT

Using footprints of boxers taken at different dates, before and after training, and before and after fighting, in the amateur's ring. It shows the reproducibility of the software instrument HC, the ones is the objective of this paper, this compared software, with the manual method proposed by (Aguado Jodar, 1997), have had obtained a high coefficient of Lin's concordance correlation (>0.98), and also graphically using Bland – Alman. Both methods of measurement are within limits 0.944623 to 0.99959.

KEY WORDS: Foot, Sports Biomechanics, Sports Sciences.

RESUMEN

Usando plantografías de boxeadores tomadas en diferentes fechas (antes y después de entrenar y antes y después de pelear en el rin amateur), se muestra la reproductibilidad del Instrumento HC (que es un software) que es el objetivo de

este trabajo, comparando este software con el método manual propuesto en (Aguado Jodar, 1997), obteniéndose un elevado coeficiente de correlación de concordancia de Lin (>0,98), además de manera gráfica usando Bland – Altman ambos métodos de medición están dentro de los límites 0,944623 a 0,99959.

PALABRAS CLAVE: Pie, Biomecánica Deportiva, Ciencias del Deporte.

INTRODUCTION

The agreement between measurements can be altered not only by the variability of the observers, but the variability of the measuring instrument or measuring process itself if performed at different times. Repeatability: indicates the extent to which an instrument provides similar results when applied to the same person more than once, but under identical conditions. Concordance intra - observer is to assess the degree of consistency in the measurement of an observer himself. Concordance inter - observer refers to the consistency between two different observers when evaluating the same measure in the same individual. (Fernández S. & Díaz S., 2004)

The term reliability is commonly used as a synonym of repeatability, reproducibility and concordance. The term validity refers to whether the procedure is actually measuring the phenomenon to be measured (Latour, Abraira, Hair, & López Sánchez, 1997).

According to (Devi Bastida, Mengual, Membrado, & Algueró, 2004) the test inter - observer above 0.7 is good reliability intra - observer.
This paper's main objective is to measure the reproducibility of HC instrument as a tool to be used in research in biomechanics.

Finally, the instrument HC is a computer program which is found on pageSourceforge.NET in Biomechanics project in the package the folder Biomechanics FootPrint and which is formed of two files HC.zip (which unpacks into a folder work either) and ImgHCorvo.zip (which unpacks into the root c of your computer).

METHODOLOGY

To verify the reproducibility of the instrument HC footprints taken for a sample of 32 of 3 boxers, where each footprint defining a test for that instrument, after that the footprints were scanned for Hernandez Corvo (1990) methodology (Aguado Jodar, 1997) in using the HC instrument is calibrated for each test (to check validity), to verify the agreement inter - observer a student at the School of Physical Culture

performed the protocol Hernández Corvo in such footprint finally in Excel 2007 Microsoft will verify the agreement between the instruments used and then calculate the coefficient LIN correlation matching to verify the reproducibility.

Taking footprint was distributed as follows: For the amateur boxer (K) were taken 16 footprints before fight and after fight, before training and after training. For the amateur boxer (A) were taken 8 footprints, before training and after training. For the amateur boxer (G) were taken 8 footprints, before training and after training. In a 2-month period at random times, to enhance described in the introduction "The agreement between measurements can be altered not only by the variability of the observers, but the variability of the measuring instrument or measuring process itself if is performed at different times." and cause the un agreement.

The correlation and linear regression are insufficient to assess the agreement between two methods (but a high correlation does not automatically imply that there is agreement between the two methods (Wikipedia, 2009)) but there is a need for a summary index to assess the reproducibility of measurements. This index was developed by Lin (1989) and is called the concordance correlation coefficient. Lin showed that the method of assessing reproducibility is higher than the comparison of coefficients of variation (B. Mandeville, 2007), paired t-test (which is what is used in (Tzvetkov, 2009)), regression, Pearson correlation (that is what is used in (Tzvetkov, 2009)) and intra - class correlation (which is what is used in (Barton, Bonnanno, & Menz, 2009)), also showed that the test is robust. (B. Mandeville, 2007).

Lawrence Lin gave a correlation coefficient of agreement (Wikipedia, 2008) as:

$$r_c = \frac{2 * Cov_{xy}}{S_x^2 + S_y^2 + (\bar{x} - \bar{y})^2}$$

Where

$$S_x^2 = \frac{1}{n}\sum_{n=1}^{n}(x_n - \bar{x})^2$$

$$Cov_{xy} = \frac{1}{n}\sum_{n=1}^{n}(x_n - \bar{x})(y_n - \bar{y})$$

Having the following properties (Lawrence I-Kuei, 1989):

i) $-1 <= -|r| <= r_c <= |r| <= 1$, r= Pearson correlation coefficient.
ii) $r_c = 0 \Leftrightarrow r = 0$
iii) $r_c = r \Leftrightarrow Sx = Sy$ y $\bar{x} = \bar{y}$
iv) $r_c = \pm 1 \Leftrightarrow$
    a. r=±1, Sx=Sy y $\bar{x} = \bar{y}$ or equivalent.
    b. Each pair of data is equal (1,1; 2,2; 3,3; 4,4; 5,5) → $r_c = 1$ or

c. Data are perfectly in reverse position (5,1; 4,2; 3,3; 2,4;1,5) → r_c=-1

The agreement was used with the square of Pearson Correlation Coefficient in the tables made in Excel. Graphic was created Bland – Altman to show the differences between the methods of measurement (using Excel).

I used the program Excel (Microsoft, 2007) and the program CCLIN (Buendía Lozada, 2009), to perform the above calculations.

The units of measurement shall be those used in the HC instrument to calibrate the results, in this case were used centimeters is the proposed method (Aguado Jodar, 1997) which is the methodology proposed in this paper.

The other observer reproducibility was performed as: Observer 1 Hernández Corvo methodology manually, Observer 2 using the application of computing HC proposal; this to prove both (assessing the same individuals in the sample) the correlation inter – observer.

RESULTS

Then the column of each table is titled HC measurements made with the instrument of calculation and the columns with headings K, A, and G are measurements made in the footprints, made by a student at School of Physical Culture (Facultad de Cultura Física, BUAP). How to calibrate the instrument HC was adjusted to the distance between line 2 and 2', measuring with a ruler on the footprint in places corresponding to these lines and subsequently inserting this information to HC program.

In tables 1 through 8, the reproducibility is the equation of the coefficient lin's concordance, Pearson's correlation coefficient and Pearson and Concordance is the square of Pearson correlation coefficient.

Table 1: Analysis of reproducibility

K	HC	K1	HC	k2	HC	k3	HC	k4
x	8.03309377	8.1	7.95011327	8	8.03899765	8	7.77406442	7.8
y	3.46987313	3.8	4.16016872	3.7	3.84845217	3.5	2.96870119	3.3
ay	3.63342592	3.6	3.54895088	3.6	3.54924796	3.6	3.82461193	3.7
ta	5.48471787	5.6	5.93473977	5.6	5.68410351	5.5	5.29583874	5.5
%x	56.80527	53.0864198	47.67158	53.75	52.12771	56.25	61.81275	57.6923077
Pearson=r		0.99751169		0.99242647		0.99672211		0.99567665
Agreement =r^2		0.99502957		0.98491029		0.99345497		0.991372
Reproducibility=Lin		0.9952059		0.98667365		0.99392911		0.99354758

Table 2: Analysis of reproducibility

K	HC	K5	HC	K6	HC	K7	HC	K8
x	7.91929263	7.3	7.96262718	7.9	7.89685642	8	7.98504984	8
y	3.28787288	3.3	3.52584874	3.5	3.26025018	3.3	3.08284889	3.3
ay	3.70446578	3.8	3.86408347	3.7	4.03202891	4	4.15520604	4.2
ta	5.53349147	5.7	5.7936019	5.6	5.90962476	5.8	5.50679915	5.7
%x	58.48275	54.7945205	55.72003	55.6962025	58.71458	58.75	61.39224	58.75
Pearson=r		0.9929742		0.99923639		0.99912039		0.9992217
Agreement $=r^2$		0.98599777		0.99847336		0.99824156		0.99844401
Reproducibility=Lin		0.98210879		0.99725983		0.99903242		0.99668263

Table 3: Analysis of reproducibility

K	HC	K9	HC	K10	HC	K11	HC	K12
X	7.83716147	7.8	7.55213147	7.7	7.94044842	7.9	7.90324484	8
Y	3.12159686	3.4	3.05958191	3.3	3.32220758	3.3	3.23378974	3.3
Ay	3.7850193	3.8	3.63083196	3.8	3.65281959	3.7	3.70520203	3.7
Ta	5.44868274	5.6	5.10482675	5.2	5.12568849	5.2	5.21439049	5.4
%x	60.16929	56.4102564	59.48717	57.1428571	58.16096	58.2278481	59.08276	58.75
Pearson		0.99861737		0.99968264		0.99970788		0.99943193
Concordancia		0.99723665		0.99936539		0.99941584		0.99886419
Reproductibilidad		0.99598346		0.99507468		0.99962472		0.99821392

Table 4: Analysis of reproducibility

K	HC	K13	HC	K14	HC	K15	HC	K16
X	7.98550258	8.1	7.89531978	7.9	8.12680116	8.1	7.93826412	7.9
Y	3.05532272	3.5	3.29581597	3.4	3.90069558	3.7	3.19055088	3.3
Ay	3.88859256	3.9	3.4898495	3.6	3.75870225	3.8	4.00774943	3.8
Ta	5.62457138	5.8	5.22329658	5.4	6.164191	6.1	5.93328755	5.7
%x	61.73913	56.7901235	58.25608	56.9620253	52.00208	54.3209877	59.80795	58.2278481
Pearson		0.99687388		0.99964529		0.99887357		0.99720632
Concordancia		0.99375753		0.99929071		0.99774841		0.99442044
Reproductibilidad		0.99126307		0.99797045		0.99821107		0.99582901

Table 5: Analysis of reproducibility

A	HC	A1	HC	A2	HC	A3	HC	A4
X	9.43221149	9.5	9.60954902	9.4	9.47756764	9.6	9.37333524	9.5
Y	3.14273766	3.4	3.28468165	3.4	4.93595678	5	4.97149061	4.9
Ay	4.68611772	4.6	4.72805262	4.6	3.14589624	3.2	3.11866486	3.2
Ta	5.46780673	5.4	5.51208284	5.5	6.27112645	6.3	6.23764157	6.3
%x	66.68079	64.2105263	65.81857	63.8297872	47.91958	47.9166667	46.96135	48.4210526
Pearson		0.99830246		0.99953014		0.99994534		0.99958962
Concordancia		0.9966078		0.9990605		0.99989068		0.99917942
Reproductibilidad		0.99805579		0.99825692		0.99947277		0.99924927

Table 6: Analysis of reproducibility

A	HC	A5	HC	A6	HC	A7	HC	A8
x	9.45477447	9.5	9.09766452	9.3	9.57625293	9.7	9.36059345	9.3
y	4.88803071	5	4.301083	4.5	3.30005061	3.5	3.50891732	3.5
ay	3.0310235	2.9	3.30476896	3.2	4.66201858	4.6	4.47054966	4.5
ta	6.26359526	6.2	6.02990327	6	6.11634066	6.1	5.61927037	5.5
%x	48.30093	47.3684211	52.72322	51.6129032	65.53923	63.9175258	62.51394	62.3655914
Pearson		0.99938394		0.99873401		0.9989871		0.999741
Concordancia		0.99876826		0.99746962		0.99797523		0.99948206
Reproductibilidad		0.99920252		0.99769594		0.99864294		0.99951681

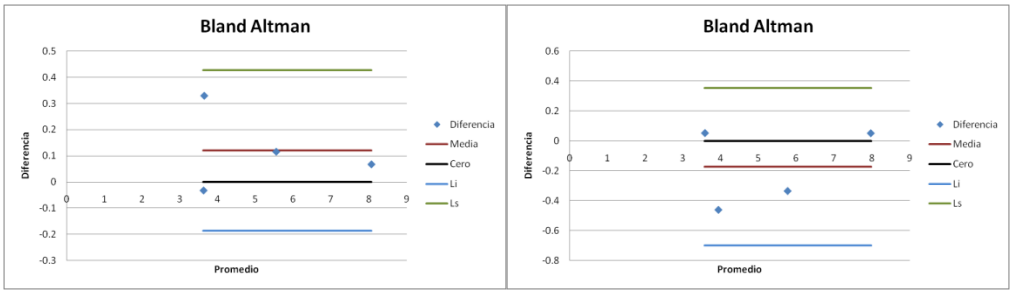
Table 7: Analysis of reproducibility

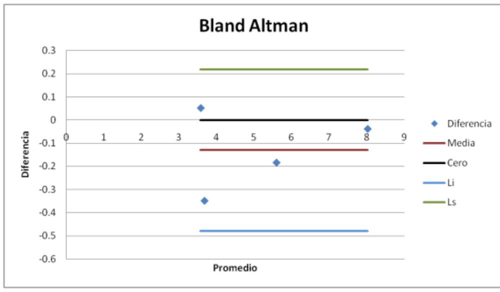
G	HC	G2	HC	G3	HC	G4	HC	G5
x	9.68660426	9.7	9.10666118	9.3	9.01722798	9.4	9.28220213	9.4
y	6.87866187	7.2	7.68109867	7.2	5.9732596	6.2	8.30127534	8.2
ay	0.58432656	0.6	0.93912187	1.2	2.27255027	1.9	0.19082043	0.1
ta	5.66189154	6	6.5401543	6.4	6.24965271	6	6.54974467	6.6
%x	28.98789	25.7731959	15.65406	22.5806452	33.75725	34.0425532	10.56782	12.7659574
Pearson		0.99890425		0.99600331		0.99765169		0.9997606
Concordancia		0.99780969		0.99202259		0.99530889		0.99952126
Reproductibilidad		0.99751707		0.99517531		0.99222872		0.99965656

Table 8: Analysis of reproducibility

G	HC	G6	HC	G7
x	9.07540651	9.4	9.27024161	9.5
y	7.40430366	7.4	6.57341419	6.4
ay	1.2625881	1.2	1.9103235	1.9
ta	6.52782284	6.3	6.40676515	6.3
%x	18.41353	21.2765957	29.09123	32.6315789
Pearson		0.99834529		0.9986657
Concordancia		0.99669332		0.99733319
Reproductibilidad		0.99772192		0.9983507

The following graph demonstrates this with the illustrations 1, 2 y 3 using the Bland – Altman, comparing the relationship between the two measurement methods (HC instrument and manually), applying the methodology of Hernández Corvo. The data compared are x, y, ay, and ta which are the result of measurements and not %x which is the result of an operation.

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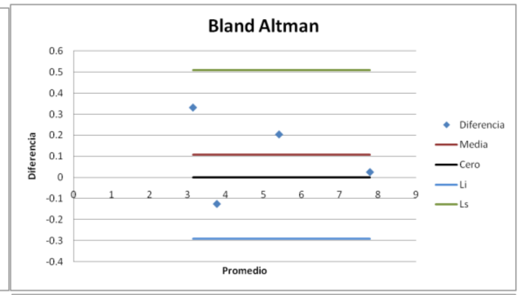
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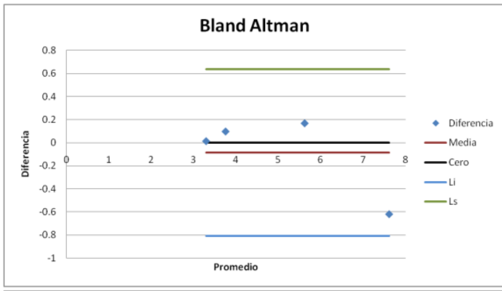
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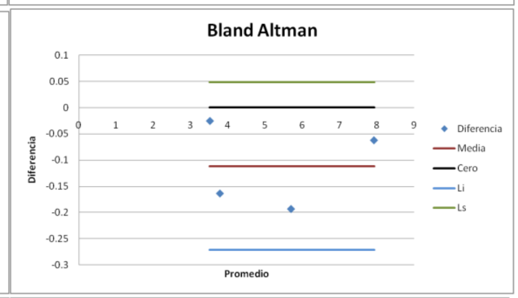
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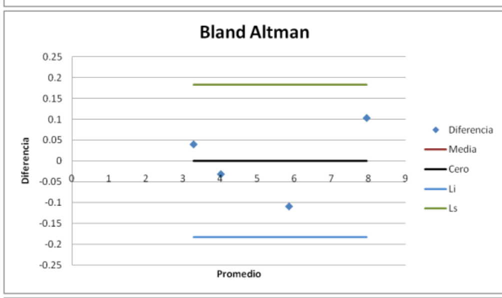
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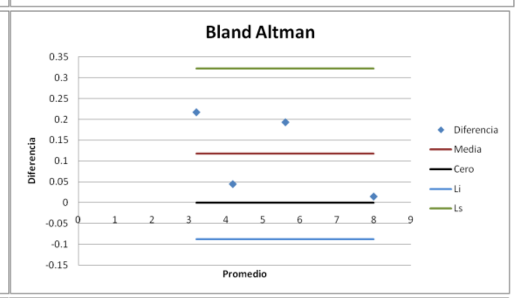
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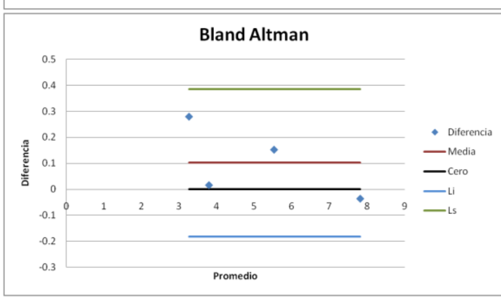
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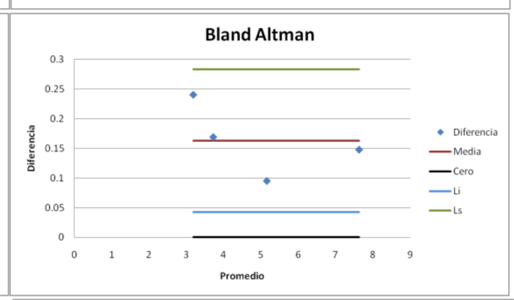
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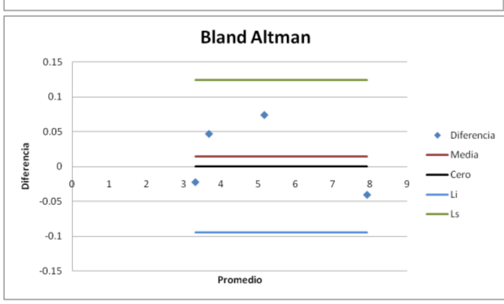
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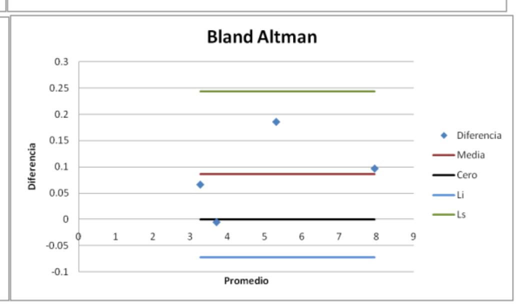
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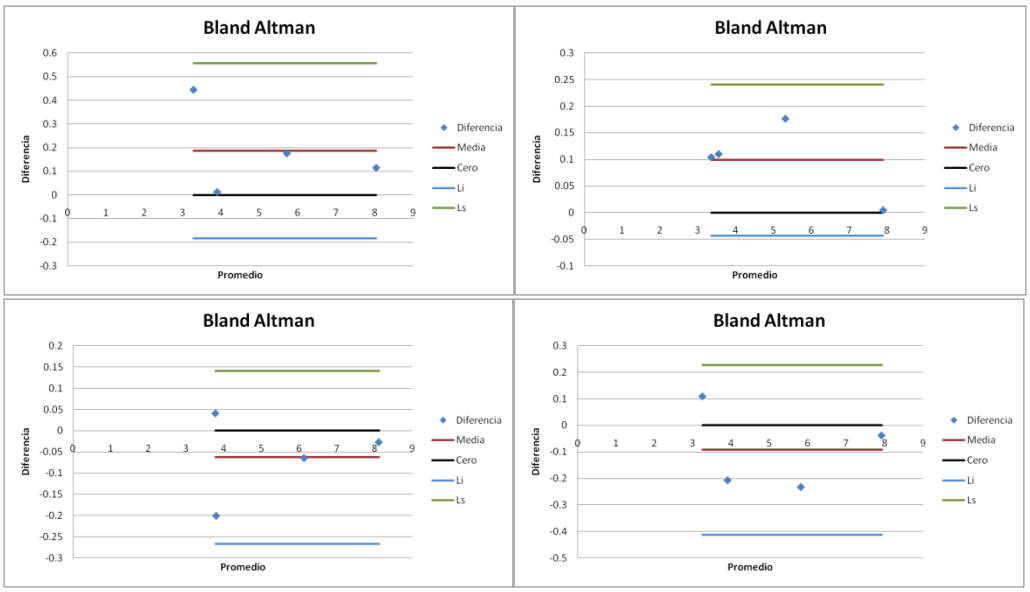
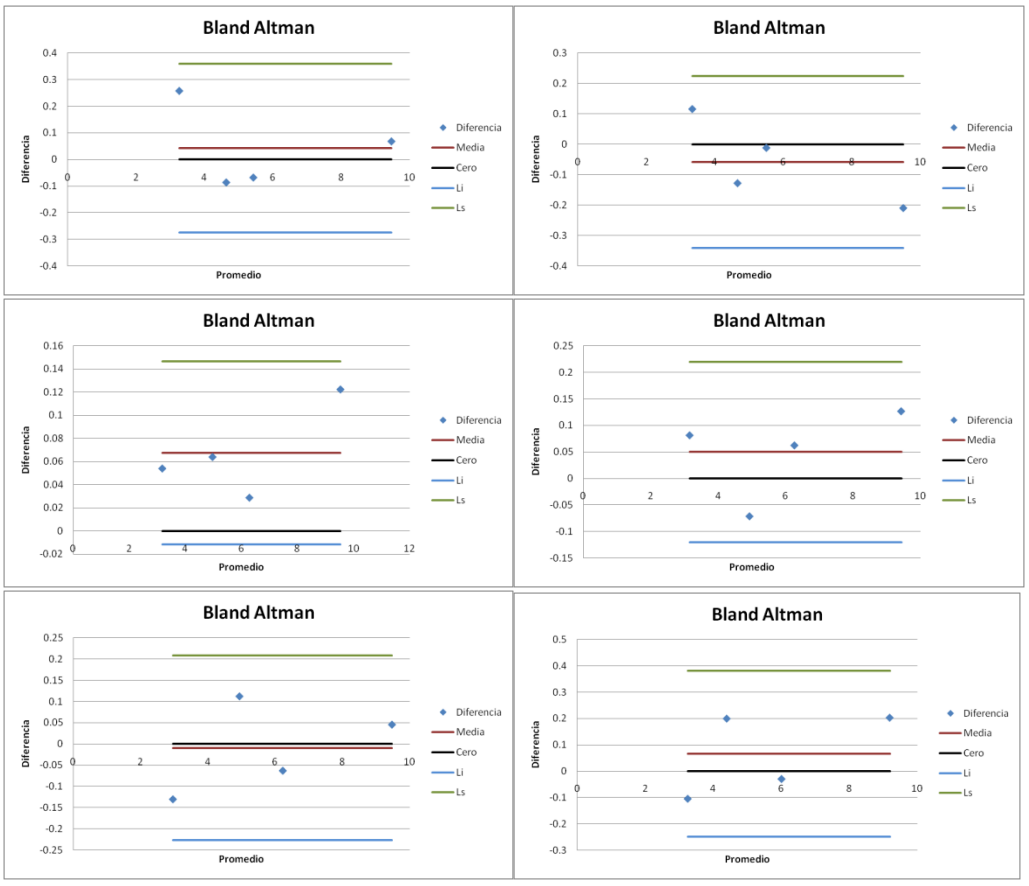


Illustration 1: Bland – Altman K Boxer vs HC (Order left to right order from top to bottom, to relate to Tables 1, 2, 3 and 4)



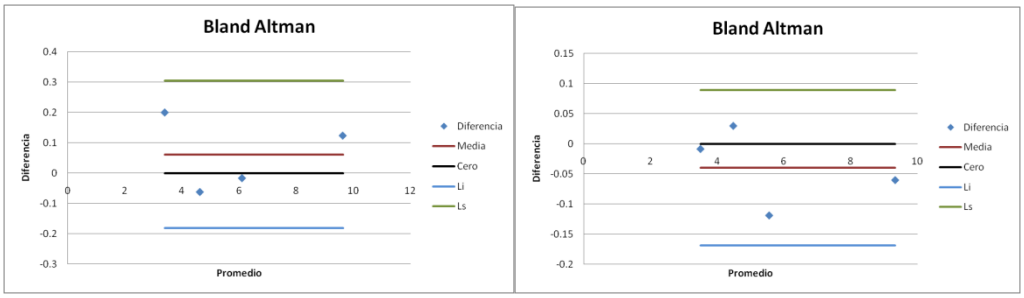


Illustration 2: Bland –Altman Boxer A vs HC (Order left to right order from top to bottom, to relate to Tables 5 and 6)

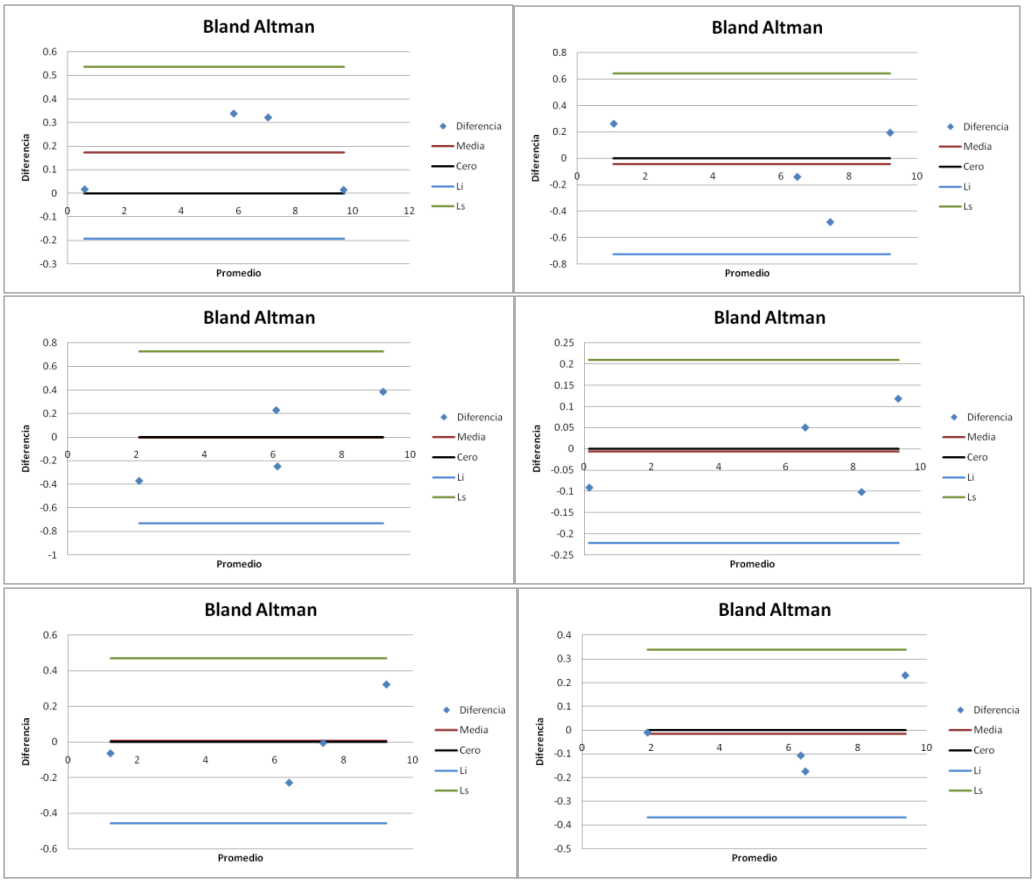


Illustration 3: Bland – Altman G Boxer vs HC (Order left to right, top to bottom, to relate Tables 7 and 8)

In the case of three illustrations above systematic error is not appreciated, and the differences are always within the limits.

CONCLUSIONS

30 tests were performed reproducibility:

- 28 reproducibility tests are greater and equal than 0.99 and
- 2 reproducibility tests are between 0.98 and 0.99.

According to CCLIN (Buendía Lozada, 2009) (Hamilton & Stamey, 2007) will have reference range from 0.944623 to 0.99959.

The limits provide only a reference and should not be used as a determinant for complete agreement between two instruments (Hamilton & Stamey, 2007).

Because the instrument has a high reproducibility HC (greater than 0.98) recommended for use if you want to work in computer equipment in research methodology Hernández Corvo, showing its use in sports biomechanics laboratory.

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