The degree of equivalence of the device PowerCal integrated in a commercial device Garmin while measuring performance in cycling

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Abstract
The aim of this work is to describe the degree of equivalence while measuring performance through device PowerCal integrated in commercial device Garmin. The principle of prediction of these data is the use of prediction equations, and monitoring of heart rate. We compared, in the context of burdening test on the ergometer Sanabike, power output in watts mediated by system PowerCal (mediated measurement of data from HR) and ergometer system Sanabike (the golden standard - direct power measurement in watts). direct power measurement in watts). The final measurements and the degree of equivalence show significant heteroscedasticity. PowerCal device exerts a considerable limits redeemable value especially in low and high levels of burdening.

Key words:
power output, heart rate, PowerCal, Garmin

Souhrn
Cílem příspěvku je postihnout míru ekvivalentnosti při měření výkonu prostřednictvím přístroje PowerCal intergrovaném v komerčním přístroji Garmin. Principem predikce těchto dat je využití predikčních rovnic a monitorování srdeční frekvence. Porovnali jsme v rámci zátěžového testu na ergometru Sanabike výkon ve watecht zprostředkovaný systémem PowerCal (zprostředkované měření z údajů SF) a systémem ergometru Sanabike (zlatý standart - přímé měření výkonu ve wattech). Výsledný měření a míra ekvivalentnosti vykazuje značnou míru heteroskedasticity. Přístroj PowerCal – Garmin tak vykazuje značné limity výpovědní hodnoty zejména v nízkých a vysokých hladinách zatížení.

Klíčová slova:
výkon, srdeční frekvence, PowerCal, Garmin

Introduction

Monitoring of burdening during physical activities with the use of modern technologies is currently very popular. It is realized in the context of sports training and while recreational physical activities. During outdoor physical activities, these tendencies are also evident. Cycling between such activities including. The use of modern technology for monitoring cycling physical activities or training burdening of athletes (cyclists) is common for several decades.

Monitoring of heart rate (HR) are commonly used in cycling, used both in the process of training and racing (Achten & Jeukendrup, 2003). As a known problem with this method of monitoring is especially HR delay compared to the current intensity of burdening. In cycling, therefore, is also used a direct measurement of the cyclists performance, which is measured by the so-called power meters (wattmeters) and is measured in watts - in this process is directly shown current power output without delay, because it is not a physiological index, but a physical indicator (Villerius, Bertucci, & Grappe, 2007).

The problem is very high purchase price of these products (eg. Comparing with monitors of HR), which are not available in this context for everyone, and are used especially in professional sport. One of the options, how the recreational cycling may reach the data of their performance, is the use of alternative determination of power output in watts while pedaling on a bicycle (further only PO) deriving for HR. Device that provides this option and its price is affordable for a broader range of candidates, is the device PowerCal (Cyclops, Madison, USA).

The company Cycleops, which produces device PowerCal, thereby indicates that it is the world‘s first power meter in which V is derived from the HR (Saris Cycling Group, 2016). Pattern under which derives V in watts from HR in pulse, is a trade secret, which the manufacturer has not shared nor referred to the published researches, where we could find out more (A. Zárybnický, personal communication, Ferbruary 25, 2015). Fundamental is the public message from manufacturer, which refers to „the analysis of tens of thousands files measuring performance over the years, researchers from the American University in the State of Colorado“ on which researchers calculated algorithms, based on the correlation of HR and PO while pedaling on a bicycle in real conditions (Saris Cycling Group, 2016). In the nineties of the twentieth century they published Arts & Kuipers (1994) very strong correlation ($r = 0.97$; $P < 0.001$) between HR and PO, but in standardized conditions. With this statement agree also (Costa, Guglielmoa, & Paton, 2015), but doubts about linearity while cycling outside laboratory conditions, ie. in outdoor environment.

The manufacturer indicates „PowerCal imbalance compared to conventional watt-meters on the physical principle in the range 10-15% of values“ (Saris Cycling Group, 2016) and he is aware that it is not such precise device, such as. PowerTap, which qualitative measurement indicators have already been verified (Duc, et al. 2007; Gardner, Stephens ,Martin, Lawton, Lee, & Jenkins, 2004).

The quality of the PowerCal measurement research verified Costa et al. (2015) – concretely validity and reliability. Criterial validity of device was found to be totally unsuitable. Authors investigated also reliability (test-retest) by 15 sec, 30 sec and 45 sec sprints at the ergometer and they did not find significant difference, while repeated measurements by individual items. On the contrary, between some individual items (sprint time segments), they have found significant differences. Variation coefficient presents between 6,7–21,5 % and a large range of intra-subject correlation coefficient (0,39–0,92) between individual “sprint” items (Costa, et al., 2015). Unfortunately, this is the only published research of this type.

Are therefore values of quality measurement of device PowerCal sufficient to use for sports training and recreational cycling? The aim of this work is to contribute to the issue of quality of performance measurement in watts while cyclist pedaling a bicycle. Concrete task was to establish the degree of reliability and validity, of device PowerCal, ‚integrated in commercial device Garmin.

Survey methodology

In the research took part in 4 probands, two men (23 years, 180 cm, 72 kg, 22 years, 184cm. 80 kg respectively) and two women (21 years, 172, 62 kg, 21, years 167 cm. 58 kg respectively). All were acquainted with the burdening protocol and they experienced it in the past.

Description of burdening protocol and equipment

Burdening protocol consisted of three phases, and the data were recorded in the research in phase 2. In the first phase proband went through the initial warm-up on the cycloergometer Sanabike 250 (Ergosana, Gmbh, Germany in the length 2x3 minutes, with burden 60 and 120 W (men) respectively 40 and 80 W for women. Then proband continuously moved to the phase 2, in which was the burden escalating from starting 60 W (men) respectively 40 W (women) gradually (step protocol) to vita maximum. Burden was increasing every minute by 30 W (men) and 20 W (women). Proband was informed about the observance the same cadence throughout whole test in the range + 5 turns per minute. The option of optimal cadence made every proband on the basis of subjective feelings in phase 1. Every finished minute of the test, the data of power output was recorded, from the system Garmin and the integrated system in cycloergometer Sanabike. Within the system, Garmin was recorded also heart rate data, and more, in the research unrated data. After completion of phase 2, followed relaxation phase 3 – running off at a lower intensity.

Parallel power measurements from both systems (Garmin and Cycloergometer) was then compared within mathematical-statistical procedures with use of Bland-Altman graf. As reference method was chosen data gained from cycloergometer Sanabike 250.

Table 1 Results of proband 1 (man). Data of power output and heart rate measured by Garmin system and data of PO measured by reference methods (cycloergometer Sanabike 250).

Order of section	Length of section (min:sec)	Average HR (pulse.min-1)	Average PO (W) Cycloergometer	Average PO (W) Garmin	Difference of measurement
1	1:01.1	114	60,00	119,00	-59,00
2	1:00.1	114	90,00	110,00	-20,00
3	0:59.9	122	120,00	138,00	-18,00
4	0:59.9	131	150,00	161,00	-11,00
5	1:00.6	137	180,00	177,00	3,00
6	0:59.2	143	210,00	193,00	17,00
7	1:00.2	150	240,00	213,00	27,00
8	0:59.5	157	270,00	220,00	50,00
9	1:00.3	163	300,00	239,00	61,00
10	0:59.7	170	330,00	263,00	67,00
11	1:00.6	173	360,00	257,00	103,00
12	0:59.6	176	390,00	259,00	131,00
Avereage					29,25
SD					52,89

Table 2.Results of proband 2 (man). Data of power output and heart rate measured by Garmin system and data of PO measured by reference methods (cycloergometer Sanabike 250).

Order of section	Length of section (min:sec)	Average HR (pulse.min-1)	Average PO (W) Cycloergometer	Average PO (W) Garmin	Difference of measurement
1	1:01.2	112	60,00	128,00	-68,00
2	0:59.9	115	90,00	121,00	-31,00
3	0:59.9	123	120,00	153,00	-33,00
4	0:59.8	130	150,00	145,00	5,00
5	1:01.2	137	180,00	178,00	2,00
6	0:58.4	142	210,00	187,00	23,00
7	0:59.8	149	240,00	202,00	38,00
8	1:07.1	155	270,00	218,00	52,00
9	0:53.5	161	300,00	238,00	62,00
10	1:00.1	167	330,00	247,00	83,00
11	1:01.3	173	360,00	266,00	94,00
Avereage					20,64
SD					48,86

Table 3 Results of proband 3 (woman). Data of power output and heart rate measured by Garmin system and data of PO measured by reference methods (cycloergometer Sanabike 250).

Order of section	Length of section (min:sec)	Average HR (pulse.min-1)	Average PO (W) Cycloergometer	Average PO (W) Garmin	Difference of measurement
1	1:00.2	104	40,00	156,00	-116,00
2	1:00.7	109	60,00	156,00	-96,00
3	0:59.9	119	80,00	175,00	-95,00
4	1:00.1	131	100,00	197,00	-97,00
5	0:59.3	145	120,00	213,00	-93,00
6	1:00.2	158	140,00	248,00	-108,00
7	1:00.1	171	160,00	264,00	-104,00
8	1:00.0	180	180,00	295,00	-115,00
Avereage					-103,00
SD					8,57

Table 4 Results of proband 4 (woman). Data of power output and heart rate measured by Garmin system and data of PO measured by reference methods (cycloergometer Sanabike 250).

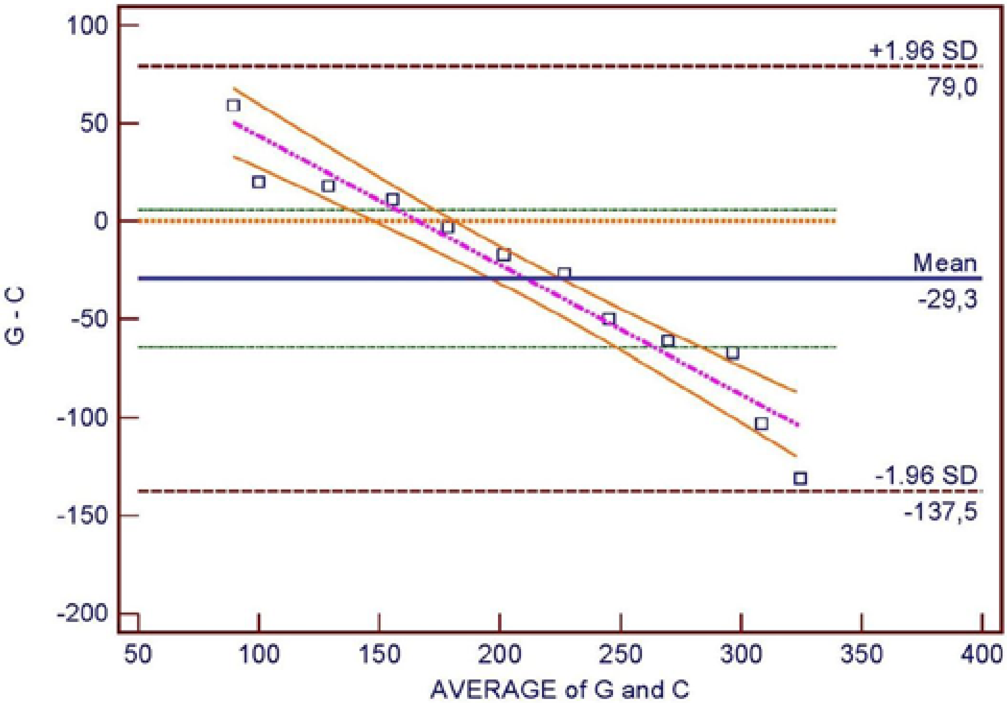
Order of section	Length of section (min:sec)	Average HR (pulse.min-1)	Average PO (W) Cycloergometer	Average PO (W) Garmin	Difference of measurement
1	1:00.2	132	40,00	156,00	-116,00
2	1:03.4	133	60,00	156,00	-96,00
3	1:01.9	144	80,00	175,00	-95,00
4	0:55.4	153	100,00	197,00	-97,00
5	1:01.8	162	120,00	213,00	-93,00
6	0:57.5	170	140,00	248,00	-108,00
7	1:00.7	176	160,00	264,00	-104,00
Avereage					-101,29
SD					7,78

Results and discussion

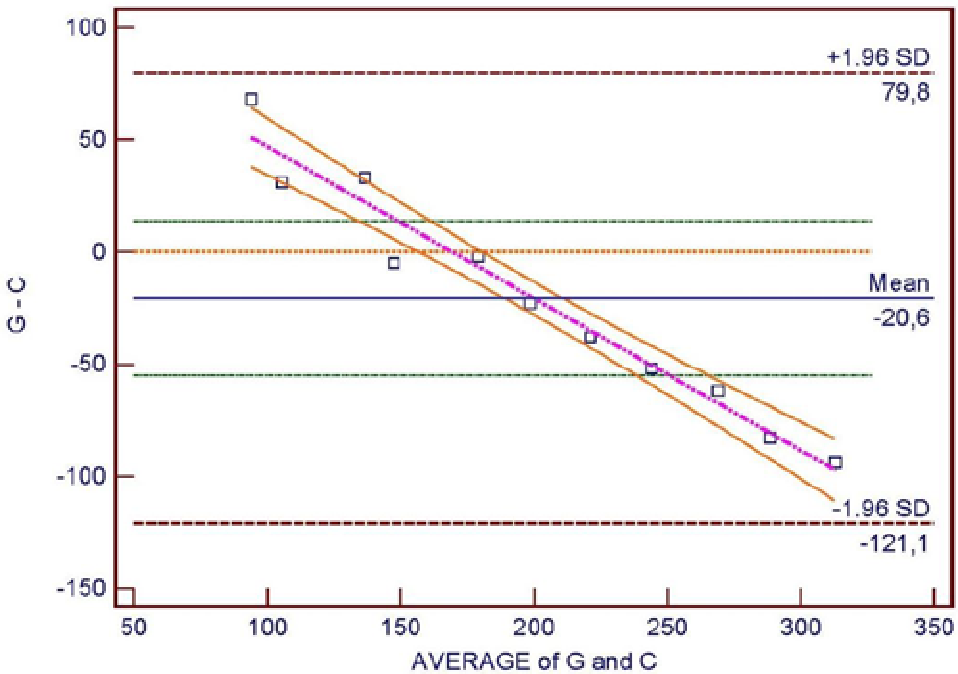
Correlation coefficients used in the paired comparison of the individual power values determined by parallel methods (Garmin and Cycloergometer; Tab. 1–4) established by regressive analysis, showing a high degree of dependence - values in the range 0,98–0,99. The fact, that parallel measurements significantly correlated among themselves, says nothing about their actual conformity. These informative value limits of the correlation coefficient in the comparison of two methods are based on minimal sensitivity to systematic overestimation or underestimation of some of these methods. Single fact that the repeated measurements significantly correlate among themselves, yet says nothing about their actual conformity. Low information potential has also graphical representation of the dependency rate - correlogram.

Therefore, in the context of our study was used the method of Bland-Altman graph.

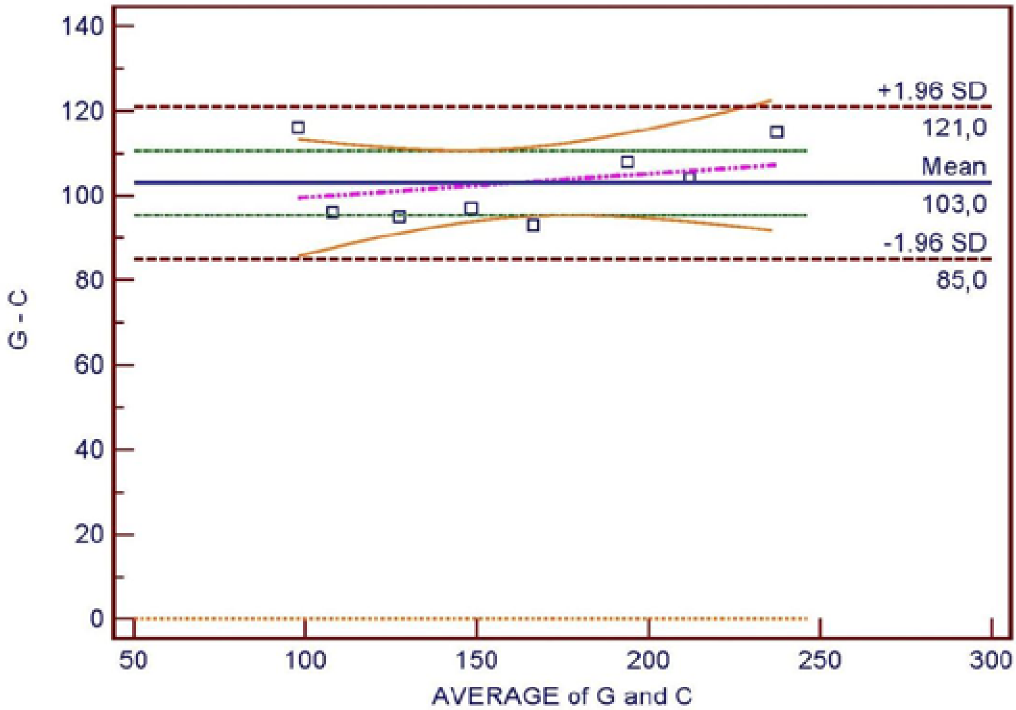
Graph 1 Proband 1 (men) – Bland-Altman graph of the depending averages of parallel measurements (axis X) and their differences (axis Y). Positions of average differences are marked and positions 95% limits of conformity (G-Garmin data, C-cycloegometer data).



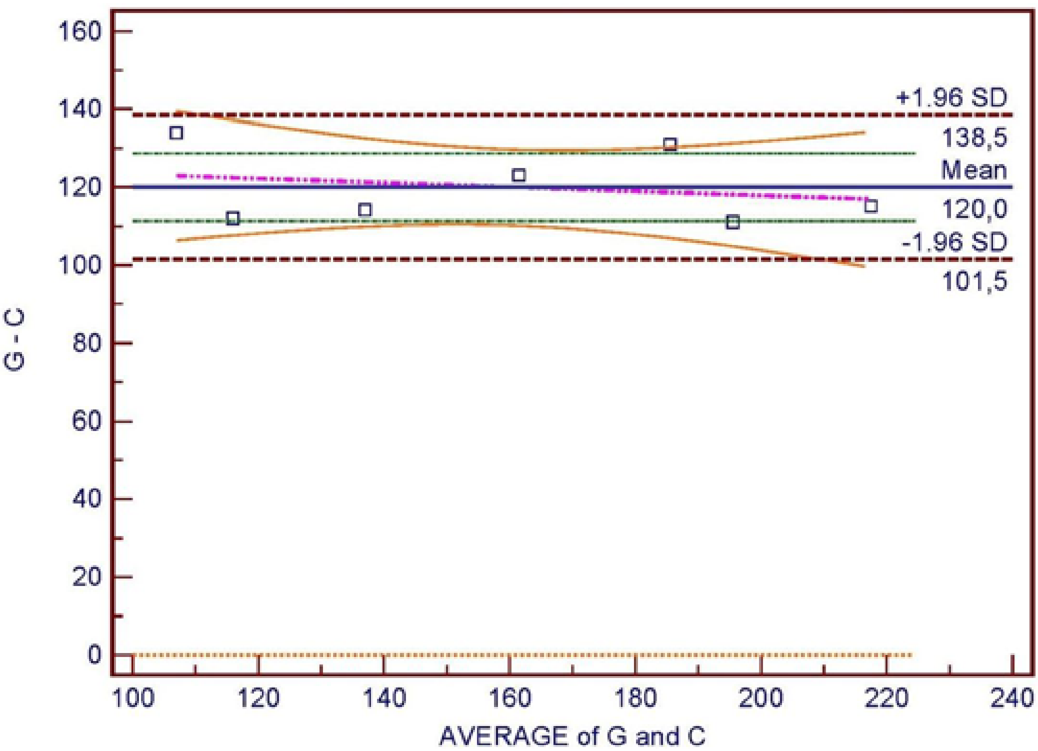
Graph 2 Proband 2 (men) – Bland-Altman graph of the depending averages of parallel measurements (axis X) and their differences (axis Y). Positions of average differences are marked and positions 95% limits of conformity (G-Garmin data, C-cycloegometer data)..



Graph 3 Proband 3 (women) – Bland-Altman graph of the depending averages of parallel measurements (axis X) and their differences (axis Y). Positions of average differences are marked and positions 95% limits of conformity (G-Garmin data, C-cycloegometer data).



Graph 4 Proband 4 (women) – Bland-Altman graph of the depending averages of parallel measurements (axis X) and their differences (axis Y). Positions of average differences are marked and positions 95% limits of conformity (G-Garmin data, C-cycloegometer data).



By visual inspection can be detected within the graphs 1 and 2 heteroscedasticity, i.e. differences increase with increasing value. In our case, we follow this trend in both directions from the average power output.
In graphs 3 and 4 is clearly detectable significant deviation from the zero difference. In these cases, (girls and burdening protocol, starting at 40 W graded by 20 W every minute) are power values generated by the device Garmin systematically higher in the entire measurement range (95% confidence interval differences from 85 W to 121 W, respectively from 101.5 to 138.5 W W).
Within the discussion, it is necessary to highlight the fact prediction data characterizing performance is based on quality of dataming respectively commercial companies, hence the quality of prediction equation. Results of our research significantly point to the limits of notice value of a particular model. It is possible that further development in this area and accumulation of data, we can expect more accurate prediction equations towards better estimation of various performance parameters. Reliable standard then remains currently only as direct measurements of specific parameters. This trend is noticeable especially in professional and performative performing of outdoor physical activities. Generally, we believe that the heart rate is not optimal parameter for predicting the derived data, by its very nature, the physiological phenomenon, which is influenced by many others, under the prediction equations hardly detectable parameters.

Conclusion

Differences of power outputs diagnosed through device Garmin and system PowerCal compared to the reference method show significant heteroscedasticity and differences depend on the size of the value measured performance. For this reason, the data provided by Garmin device have only roughly approximate value and can not be responsibly used to detect the values of the current power output. Partially corresponds to reality only in the area of average performance. Thus, while burdening on the low intensity conversely in intensities submaximal and maximal do not match the values detected by the reference method.
For the above reasons, we recommend to continue in examine the quality of measuring by device PowerCal supplied with a commercial device Garmin while measuring performance in cycling. We believe that this can be achieved by enriching knowledge not only in the area of methodology of performance measurement but also the practical use in the management of physical activities in outdoor activities. We believe that the device can be successfully used in school practice. Firstly, in physical education, both in the context of inter-subject relations. Physical and physiological parameters and their relationship can be also demonstrated. It is used in subjects such as physics, mathematics, biology. For use in sports training, the device exhibits an insufficient degree of validity and reliability.

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