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Investigation into the validity of the speed indications of the treadmill h/p/cosmos pulsar 3p 4.0

1 Problem statement

By now treadmills and treadmill-ergometers belong to the valid standard test and training devices of sports scientific and sports medical institutions, rehabilitation facilities or fitness clubs. Especially when taking the necessity of precise load dosage and reproduction of performance diagnostic tests into account, treadmill-ergometers are indispensable. But not only in diagnostics also in training resp. therapy processes its application is exceedingly useful.

For years for the scientific work on walking and running legitimate doubts have been raised, whether the serious intervention into the movement structures caused by the compulsory circumstances due to construction restrains, is tenable. However, not only the validity of research performed on a treadmill in a scientific setting is being put into question (problem „treadmill versus walking lane“) but also the reliability of the pre-set treadmill speed is being doubted at times.

Bio-kinematic research by Wieck et al. (1997) showed a speed reduction of the running belt of 25% at a speed of 4 m/s (14,4 km/h) on a treadmill with running belt in the standing phase of the subject. In comparison the speed reduction on a treadmill with a T-slat belt at the same speed was merely 3%. If the speed of a treadmill in the standing phase of the subject differs widely from the pre-set value, the results of the gait-analytic test are not reproducible and therefore not valid anymore (Wiek et al., 1997, S. 2).

Compared with this, Leuchte, Faber & Speer (2001) found variations of about 5% at a treadmill speed between 2 km/h and 15 km/h, while the actual running belt speed was generally above the pre-set treadmill speed. They concluded from this that, the drive ensured

reliable working with treadmills within the performance limitations named by the manufacturers.

This inconsistent data situation makes clear that, especially approaching a scientific study with treadmills it is necessary to check their validity in connection with different parameters (belt speed, load, elevation etc.) and to quantify the respective measurement errors.

Actually following questions have to be answered:

1. How big is the deviation between the pre-set treadmill speed and the actually measured treadmill speed?
2. What impact has the elevation got on the pre-set treadmill speed?
3. What impact has the body weight got on the treadmill speed?
4. Is the speed deviation dependent on the treadmill speed (higher speed = higher deviation?)?

5. What could be the cause for the slight speed deviations ?

2 Research method

For the speed measurements on the h/p/cosmos pulsar 3p 4.0 treadmill three subjects with different body masses were available:

Test person A: 22 years of age, 54,0 kg, middle-distance runner

Test person B: 27 years of age, 71,6 kg, martial arts athlete

Test person C: 24 years of age, 97,6 kg, soccer player

The tests were performed by manual measurements with a stopwatch on the basis of 50 belt rotations. At a measured belt length of 4,17 m this is equivalent to a distance of 208,50 m.

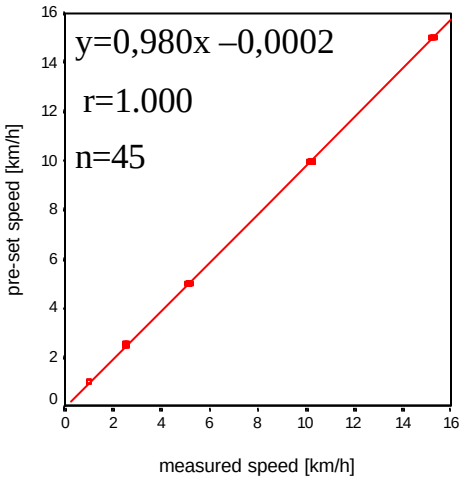
The visual-motor reaction time for the test conductor (age: 22 years) amounts to 0,23 seconds according to Roth & Winter (1994). Therefore any measurement errors of up to 0,46 s have to be defined as person-related errors and can not be added to the measurement system.

The treadmill was tested in the following variations:

a) at speeds of 1.0, 2.5, 5.0, 10.0 and 15.0 km/h without and with load (54kg, 71,6 kg, 97,6 kg)
b) at elevations of (0%, 1 %, 2.5% 5.0%, 10%, 15% and 20%) without and with load (97,6 kg) at 5 km/h and at 10 km/h

3 Results

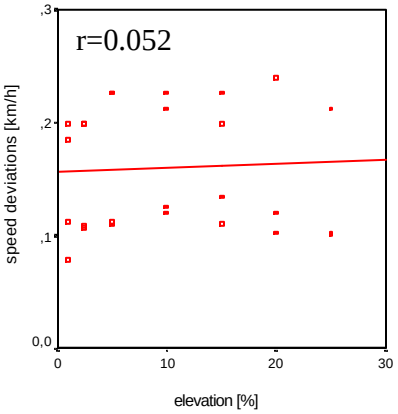
ad 1) How big is the deviation between the pre-set treadmill speed and the actually measured treadmill speed independent load and elevation?

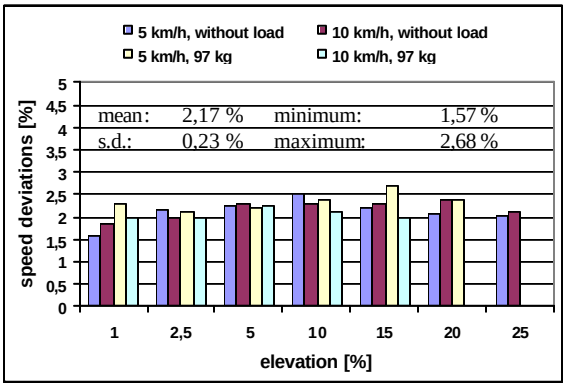


Illustr.1. Correlation analysis between pre-set and measured speed

As can be seen from the correlation analysis (r=1.000), no differences were found between the pre-set and measured speed independent of load and elevation.

ad 2) What is the influence of elevation on the pre-set treadmill speed?

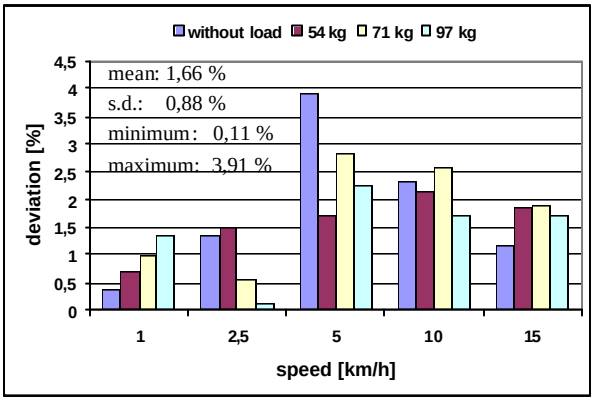




Illustr.2a-b. Correlation of speed deviations and elevation (a) as well as speed deviations in dependence on load, elevation and speed (b)

The established speed deviation stands in no relation to the elevation (r = 0,0052). The influence of the elevation on the level of speed deviation is not worth mentioning, no matter of the load variation or different speeds (Illustr. 2b).

ad 3) What is the influence of bodyweight on the treadmill speed?

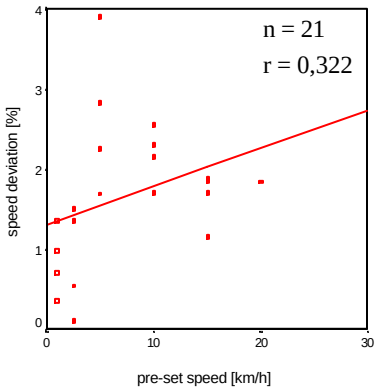


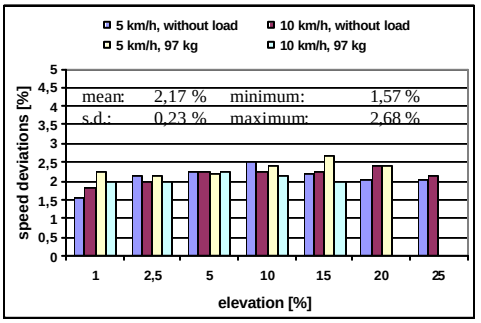
load [kg]	deviation [km/h]	
	mean	s.d.
0	0,13	0,10
54	0,14	0,13
72	0,12	0,12
98	0,11	0,11
p=0.582; Eta-Quadrat=0.111		

Illustr.3a-b. Treadmill speed deviation in percent in dependence on load (a) and variance analytical examination of the average differences (b)

The bodyweight has no influence on the level of speed deviations of the treadmill. The average deviation amounts to max. 0,14 km/h and has the tendency to appear at low load. However, these deviations have no practical relevance.

ad 4) Is the speed deviation dependent on the level of the pre-set treadmill speed?

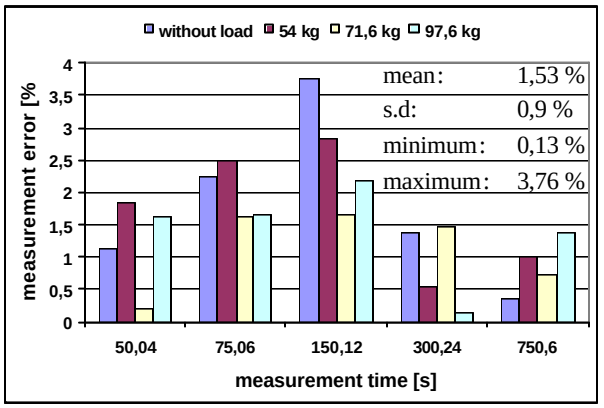


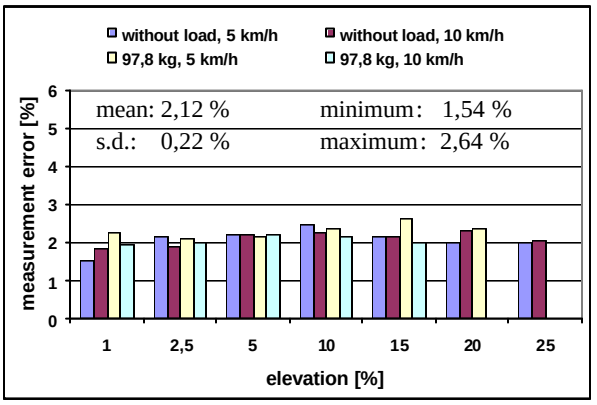


Illustr.4a-b.: Correlation of the speed deviations in percent and the pre-set speed (a) and the speed deviations in percent in dependence on load, elevation and speed (b)

The level of pre-set speed has no influence on the amount of speed deviations. The average error amounts to 1,66% independent of load and elevation and in dependence of speed, load and elevation 2,17%.

ad) 5. What is the cause of these minor deviations?





Illustr. 5a-b. Measurement errors in percent in dependence of speed and load (a) and measurement errors in percent in dependence of speed, load and elevation (b)

Related to the measurement time only minor average deviations of 1,53% are established, including manual measuring errors of up to 0,46 s, (in dependence of speed and load) and 2,12% (in dependence of elevation, load and speed).

4 Conclusion

The treadmill h/p/cosmos pulsar 3p 4.0 has a very precise speed control and fulfils the requirements for scientific research and testing. The parameters speed, load and elevation evidently have no influence on the treadmill speed pre-set at the display of the treadmill.

Literature

1. Leuchte, S., Faber, W. & Speer, A. (2001). Is the pre-set treadmill speed reliable? *Sports scientific contributions from Leipzig 27* (2), 53-65.
2. Roth, K. & Winter, R. (1994). Development of coordinative abilities. In J. Baur, K. Bös & R. Singer (Hrsg.), *Kinetic development* (S. 191-217). Schorndorf: Hofmann.)
3. Wieck, M., L. Thorwesten, L. & Verdonck, A. (1997). *The use of bio-kinetic measurement methods for the assessment of training devices*. Lecture on the occasion of the 35th German Sports Medicine Congress in Tuebingen (Abstract).

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Appendix

Overview of measurement errors at 50 revolutions

	Speed (km/h)		Deviations	
	Indicated	Calculated	Absolute	in %
Without load	1	0,9964819	0,003518	0,35181
	2,5	2,4662395	0,033760	1,35042
	5,0	5,1955423	0,195542	3,91084
	10,0	10,230339	0,230339	2,30339
	15,0	15,172832	0,172832	1,15221
	20,0	20,369064	0,369064	1,84532
	25,0	-	-	-
	30,0	-	-	-
	35,0	-	-	-
	40,0	-	-	-
With load (54 kg)	1	0,990146	0,009854	0,9854
	2,5	2,5135624	0,013562	0,54248
	5,0	5,1410959	0,141096	2,82192
	10,0	10,255499	0,255499	2,55499
	15,0	15,280945	0,280945	1,87296
	20,0	-	-	-
	25,0	-	-	-
	30,0	-	-	-
	35,0	-	-	-
	40,0	-	-	-
With load (71,6 kg)	1	0,9928571	0,007143	0,7143
	2,5	2,5376969	0,037697	1,50788
	5,0	5,0846769	0,084677	1,69354
	10,0	10,215024	0,215024	2,15024
	15,0	15,277834	0,277834	1,85222

	20,0	-	-	-
	25,0	-	-	-
	30,0	-	-	-
	35,0	-	-	-
	40,0	-	-	-
With load (97,6 kg)	**1**	**0,9864634**	**0,0135366**	**1,35366**
	2,5	**2,5028343**	**0,0028343**	**0,113372**
	5,0	**5,113079**	**0,113079**	**2,26158**
	10,0	**10,170732**	**0,170732**	**1,70732**
	15,0	**15,256098**	**0,256098**	**1,70732**
	20,0	-	-	-
	25,0	-	-	-
	30,0	-	-	-
	35,0	-	-	-
	40,0	-	-	-

Overview of measurement errors at 50 revolutions (=208,50 m)

	Speed (km/h)	Time (s)		Deviations	
		Calculated	Measured	Absolute	In %
Without load	1	750,6	753,25	2,65	0,3530
	2,5	300,24	304,35	4,11	1,3689
	5,0	150,12	144,47	5,65	3,7636
	10,0	75,06	73,37	1,69	2,2515
	15,0	50,04	49,47	0,57	1,1391
	20,0	37,53	36,85	0,68	1,8118
	25,0		-	-	-
	30,0		-	-	-
	35,0		-	-	-
	40,0		-	-	-
With load (54 kg)	1	750,6	758,07	7,47	0,9952
	2,5	300,24	298,62	1,62	0,5395
	5,0	150,12	145,60	4,25	2,8310
	10,0	75,06	73,19	1,87	2,4913
	15,0	50,04	49,12	0,92	1,8385
	20,0		-	-	-
	25,0		-	-	-
	30,0		-	-	-
	35,0		-	-	-
	40,0		-	-	-
With load (71,6 kg)	1	750,6	756,0	5,4	0,7194
	2,5	300,24	295,78	4,46	1,4854
	5,0	150,12	147,62	2,5	1,6653
	10,0	75,06	73,84	1,22	1,6253
	15,0	50,04	49,13	0,91	0,1998

	20,0		-	-	-
	25,0		-	-	-
	30,0		-	-	-
	35,0		-	-	-
	40,0		-	-	-
With load (97,6 kg)	**1**	**750,6**	**760,90**	**10,3**	**1,3722**
	2,5	**300,24**	**299,93**	**0,31**	**0,1325**
	5,0	**150,12**	**146,84**	**3,28**	**2,1849**
	10,0	**75,06**	**73,81**	**1,25**	**1,6653**
	15,0	**50,04**	**49,22**	**0,82**	**1,6386**
	20,0		-	-	-
	25,0		-	-	-
	30,0		-	-	-
	35,0		-	-	-
	40,0		-	-	-

Results – Overview of measurement errors at 50 revolutions

	Speed in km/h		Deviations	
	Indicated	Calculated	Absolute	In %
Without load – elevation in %				
1	5,0	5,0781409	0,0781409	1,56818
2,5	5,0	5,1082074	0,1082074	2,164148
5,0	5,0	5,1116862	0,1116862	2,233724
10,0	5,0	5,1256487	0,1256487	2,512974
15,0	5,0	5,1106421	0,1106421	2,212842
20,0	5,0	5,1026513	0,1026513	2,053026
25,0	5,0	5,1019576	0,1019576	2,039152
Without load				
1	10,0	10,184532	0,184532	1,84532
2,5	10,0	10,19837	0,19837	1,9837
5,0	10,0	10,226158	0,226158	2,26158
10,0	10,0	10,226158	0,226158	2,26158
15,0	10,0	10,226158	0,226158	2,26158
20,0	10,0	10,240109	0,240109	2,40109
25,0	10,0	10,212245	0,212245	2,12245
With load (97,6 kg)				
1	5,0	5,113079	0,113079	2,26158
2,5	5,0	5,1061224	0,1061224	2,122448
5,0	5,0	5,1095984	0,1095984	2,191969
10,0	5,0	5,1200546	0,1200546	2,401092
15,0	5,0	5,1340629	0,1340629	2,681258
20,0	5,0	5,1200546	0,1200546	2,401092
25,0	5,0	-	-	-
With load (97,6 kg)				
1	10,0	10,19837	0,19837	1,9837
2,5	10,0	10,19837	0,19837	1,9837

5,0	**10,0**	**10,226158**	**0,226158**	**2,226158**
10,0	**10,0**	**10,212245**	**0,212245**	**2,12245**
15,0	**10,0**	**10,19837**	**0,19837**	**1,9837**
20,0	**10,0**	**-**	**-**	**-**
25,0	**10,0**	**-**	**-**	**-**

Results – Overview of measurement errors at 50 revolutions (=208,50 m)

	Speed in km/h	Time in s		Deviations	
		Calculated	Measured	Absolute	In %
Without load - elevation in %					
1	5,0	150,12	147,81	2,31	1,538769
2,5	5,0	150,12	146,94	3,18	2,118305
5,0	5,0	150,12	146,84	3,28	2,18492
10,0	5,0	150,12	146,44	3,68	2,45137
15,0	5,0	150,12	146,87	3,25	2,164934
20,0	5,0	150,12	147,10	3,02	2,011724
25,0	5,0	150,12	147,12	3,0	1,998401
Without load					
1	10,0	75,06	73,68	1,38	1,838529
2,5	10,0	75,06	73,63	1,43	1,891819
5,0	10,0	75,06	73,41	1,65	2,198241
10,0	10,0	75,06	73,38	1,68	2,238209
15,0	10,0	75,06	73,44	1,62	2,158273
20,0	10,0	75,06	73,34	1,72	2,291500
25,0	10,0	75,06	73,53	1,53	2,0383693
With load (97,6 kg)					
1	5,0	150,12	146,78	3,34	2,2248868
2,5	5,0	150,12	146,96	3,16	2,1049827
5,0	5,0	150,12	146,90	3,22	2,1449507
10,0	5,0	150,12	146,62	3,5	2,3314682
15,0	5,0	150,12	146,16	3,96	2,6378897
20,0	5,0	150,12	146,63	3,49	2,3248068
25,0	5,0		-	-	-
With load (97,6 kg)					

1	**10,0**	**75,06**	**73,62**	**1,44**	**1,9184652**
2,5	**10,0**	**75,06**	**73,56**	**1,5**	**1,9984013**
5,0	**10,0**	**75,06**	**73,43**	**1,63**	**2,1715961**
10,0	**10,0**	**75,06**	**73,47**	**1,59**	**2,1183054**
15,0	**10,0**	**75,06**	**73,56**	**1,5**	**1,9984013**
20,0	**10,0**		**-**	**-**	**-**
25,0	**10,0**		**-**	**-**	**-**