Quantifying Children's Active Play

An Experiment on Accelerometry of Self-Paced Children's Games During Guided Active Play

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Background

- The most widely used methods of quantifying physical activity (PA) throughout literature are: heart rate (HR), pedometery, and accelerometry (ACC). Evidence exists for strong linear relationships among ACC-PA (uniaxial-vertical axis; triaxial-vector magnitude) and oxygen consumption(VO_2), energy expenditure (EE), and metabolic equivalents METs using standardized or regularized PA protocols using a motorized treadmill (TM); i) ACC cut-off points (low/moderate/ vigorous); and ii) Linear regression equations to estimate EE and/or MET (1, 2).

- Literature reports that the estimates of EE and METs for unregulated children's PA (games, daily living) are significantly underestimated when using linear regression equations from ACC calibrated against regulated TM activity (2, 3).

Purpose: to determine: a) the nature of the relationships between counts from individual axes and vector magnitude (VM) for self-paced/unregulated children's games; and b) assess what impact a dominant axes may have on these relationships

Hypothesis: in a field setting where a free range of movement is allowed, children's self-paced PA does not follow a linear model and has different axis characteristics than TM activity.

Objective: to measure and analyze energy expenditure of children between the ages of 8 to 12 years of age during active play in a gymnasium setting using VM.

Methodology

Children (n=15;Table 1) were recruited from an active play community program. All procedures were approved by York's Human Participant Ethics Committee with child assent and written consent received from parents/guardians.

Treadmill: following pre-screening (2013 PARQ+) and a 10 min resting VO_2, children walked/jogged on a TM (4, 6 and 8km/h and 0% grade) for 5 minutes at each pace. VO_2 (COSMED2) and HR (using a Polar Heart Rate Monitor) were determined over 10sec intervals. Accelerometers (ActiGraph GT3X+ - right hip) were used to quantify physical activity (PA) (10sec epoch). A prediction equation (linear regression) for VO_2 using PA (vertical-axis and/or VM) were determined with and without resting values. Active Play: six cooperative games (~6 min each focused on running/jumping) were conducted in a supervised camp format (30 children; 1 hr duration; indoor gym). VO_2, HR and PA (as above) were collected continuously for each game.

Statistical Analysis:

Linear regression estimates of VO_2 (TM and 6 games) using PA (vertical and VM) versus actual VO_2 measurements were compared by Bland-Altman Plots. Intercept values for TM and games were assessed using ANOVA and Tukey Post-Hoc test at a p=0.05. Axes-dominance (relative difference between the highest and lowest axes) were compared from TM and games using ANOVA-Tukey post-hoc teat with p=0.05.

Table 1. Characteristics chart of children in KIN KIDS Guided Active Play Program

	Age (years)	Height (cm)	Mass (kg)	BMI (wt/ht^{2})	Aerobic Power (ml O_2·kg·min)
Total (n=15)	9.3 ±1.2	139.1 ±9.5	39.2 ±9.3	20.4 ±4.0	44.6 ±2.1
Girls (n=7)	9.4 ±1.0	142.6 ±7.6	40.4 ±8.8	19.8 ±3.3	45.8 ±1.9
Boys (n=8)	9.3 ±1.4	136.0 ±10.4	38.1 ±10.2	21.1 ±4.7	43.4 ±2.4

Results

During treadmill activity the linear relationships for VM with speed at 4, 6, and 8km/h and VO_2 were 0.90±0.3 for vertical axis counts and 0.89±0.05 for VM counts, (p>0.05). The measured VO_2 values for self-paced games were consistently higher at lower counts (VM) for all games. Since the pattern in Fig.1. a and b are similar, vector magnitude and vertical counts predict similar VO_2 values.

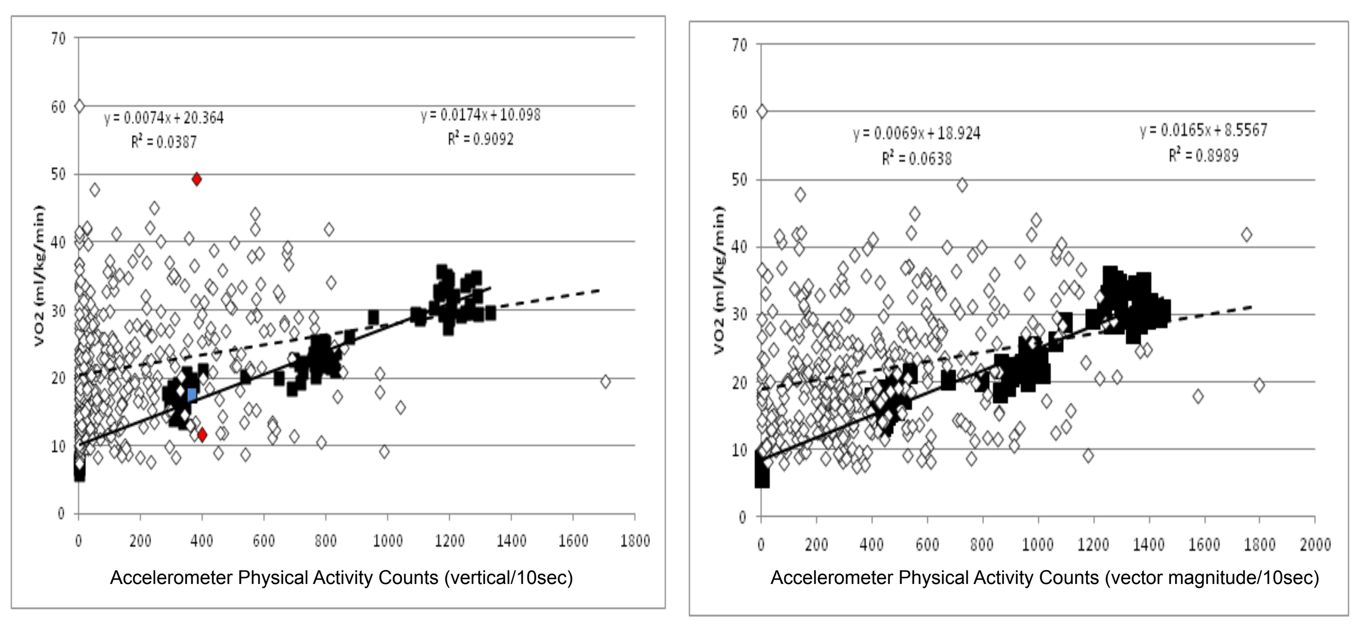

Fig. 1. Children's (n=15) oxygen consumption versus physical activity (GT3X+ counts/ 10sec epoch) measured by a) vertical axes and b) vector magnitude for treadmill activity at 4, 6, 8 km/h and active playing of games (i.e. clothespin tag, crash, fishes and whales, etc.). The solid line/markers represents treadmill activity, and the dotted line/open markers is unregulated self-paced games.

Estimation of VO_2 for unregulated children's games shows poor agreement with proportional and magnitude error bias.

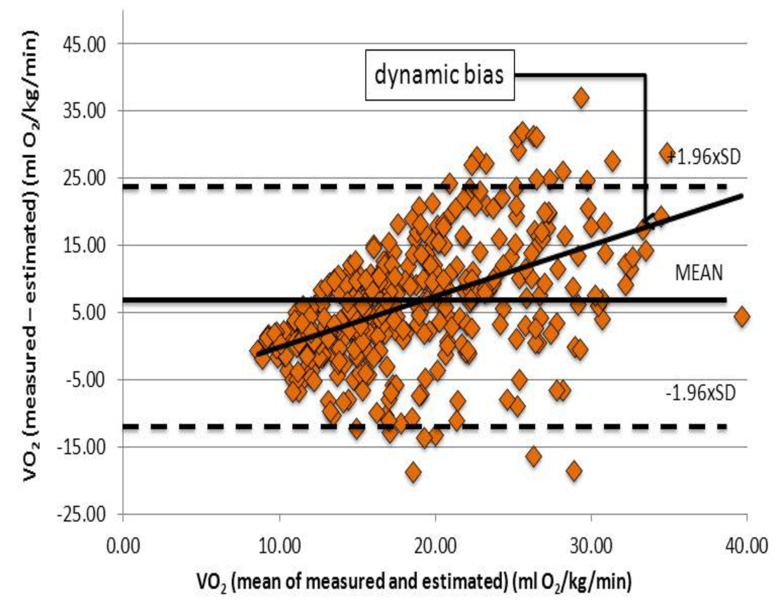

Fig.2. Bland and Altman plots of measured-Vector Magnitude estimated VO_2 (per kg) for games using a linear regression equation (*y=0.0165x +8.5567*) for Treadmill activity. Mean difference and 95% limits of agreement.

Linear regressions for each game resulted in a range of intercepts, for VM and time, from 520±198 counts/10sec to 1198±196 counts/10sec (p<0.05) compared to treadmill values of 193±95 counts/10sec (p<0.05). Unregulated self-paced children's games can take on any shape and the relationship between treadmill and the games are different. The range of activity between the lowest TM speed and the highest TM speed is similar to the range of lower intensity and higher intensity games that were played.

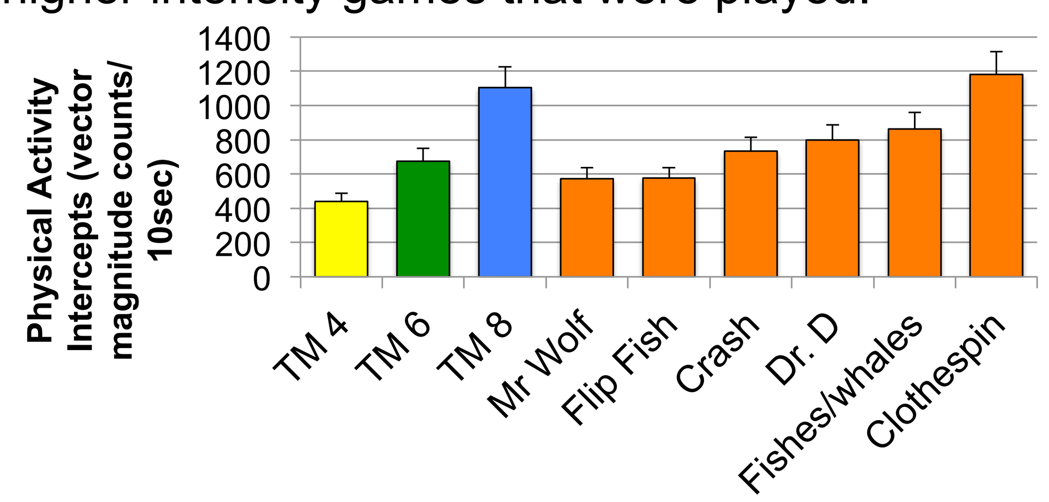

Fig. 3. Comparison of physical activity between children's (n=15) games and treadmill activity using intercept values (vector magnitude counts/10sec epoch) derived from linear regression equations. Statistical comparison using ANOVA and Tukey Post-Hoc test at a p level of 0.05.

Hypothetical calculation with standardized activity counts and varying axis contribution (Fig. 4) showed that VM counts varies with axes difference, showing that a dominant axis affects the VM max. The percent difference in axis contribution to VM between the dominant and lowest axis (Table 2) was 40±13% and 3±1.6% for treadmill activity and self-paced games, respectively (p<0.05). The contribution of axis during children's games were similar, unlike the TM activity in which there was a high percent axis difference indicating the presence of a dominant axis (vertical).

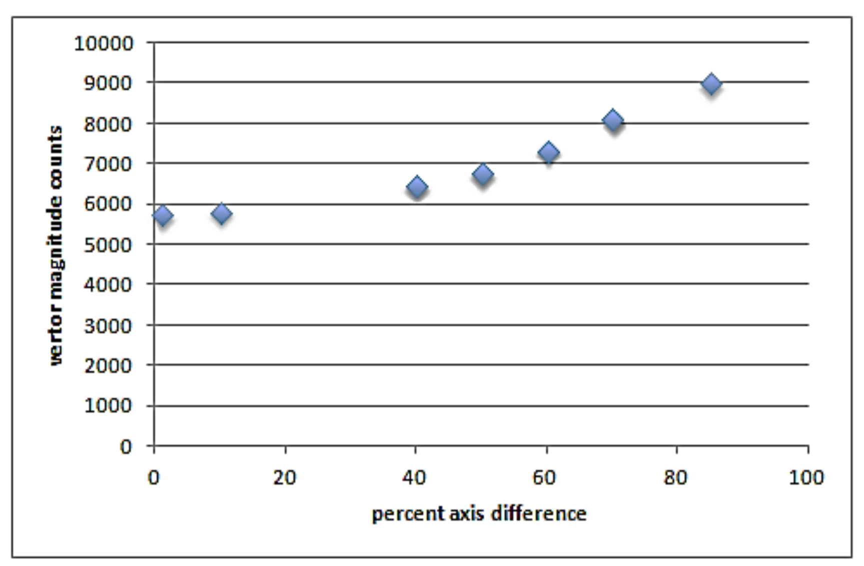

Fig. 4. Hypothetical calculation of vector magnitude using a range of percent axis difference standardized to a total of 10,000 counts.

Table 2. Axes dominance as a function of unregulated children's games and regulated treadmill activity at 4, 6, and 8 km/h. Percent axis difference for all children's games were lower than those of treadmill activity (p<0.05).

Physical Activity	Vertical %	Horizontal %	Perpendicular %	AXIS Difference %
Crash	32	33	35	3 ± 2
Clothespin Tag	37	31	32	6 ± 6
Dr. Dodge ball	32	33	35	3 ± 3
Flip Fish	35	32	33	3 ± 4
Fishes/Whales	33	34	33	1 ± 6
Mr. Wolf	31	34	35	4 ± 3
Treadmill at 4km/h	47	33	20	27 ± 13
Treadmill at 6km/h	53	33	14	39 ± 17
Treadmill at 8km/h	65	23	12	53 ± 18

Discussion & Conclusions

- TM activity is associated with increased PA (vertical and VM-Fig 1.) resulting in a significant contribution of a dominant axis (Table 2).
- The lack of a dominant axis reported for unregulated games (Table 2) may underlie the poor estimate of VO_2 for games (fig. 2).
- The variety of movement in children's self-paced PA (Fig. 3) may explain the greater mean squared error for non-TM activity (1) when using either vertical and/or vector magnitude generated equations from TM activity.
- The suggestion that axes dominance may underestimate VM may require ACC measurements of unregulated active play to use a correction factor.

References

1. Eston RG, Rowlands AV, Ingledew DK. Validity of heart rate, pedometry, and accelerometry for predicting energy cost of children's activities. J Appl Physiol. 1998;84:362-371.
2. Alhassan S, Lyden K, Howe C, Keadle SK, Nwaokelemeh O, Freedson PS. Accuracy of accelerometer regression models in predicting energy expenditure and METs in children and youth. Ped Exer Sci. 2012;24:519-536.
3. Matthews CE. Calibration of accelerometer output for adults. American College of Sports Medicine. DOI: 10.1249/01.mss.0000185659.11982.3d