Laurea specialistica in Scienze e tecniche dello sport

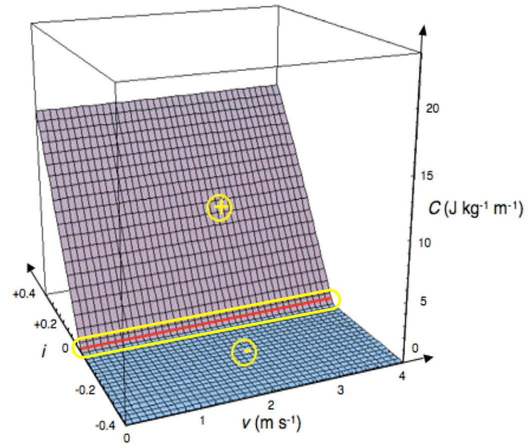
Biomeccanica del movimento e dello sport ARDIGO' 18 (2010/2011)

# La locomozione e le 'interferenze' ambientali

Mercoledì 30 Marzo h. 10:30÷12 Biomeccanica del movimento e dello sport ARDIGO' 18

Luca P. Ardigò

## $C_r$ (2)
(pendenza neutra)



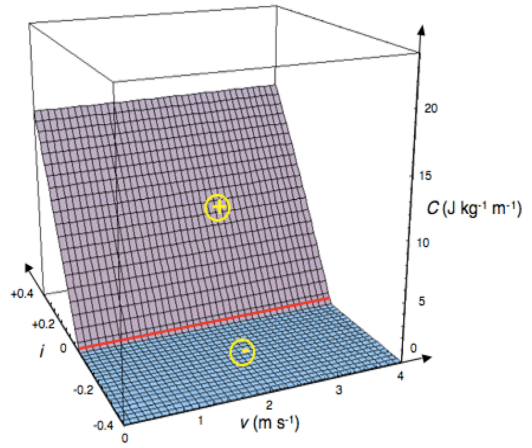

$M\ g\ (\text{pendenza}) = C_r\ M\ g$

$$C_B = \frac{0.17\,(m+9)\,\mathrm{Cos}[\mathrm{Arctan}(i)] + 0.43\,A_f\,v^2 + 39.20\,(m+9)\,\mathrm{Sin}[\mathrm{ArcTan}(i)]}{m}$$

# Pendenza

ciclismo (mtb)

C vs. pendenza/velocità




$\sin(\tan^{-1} i) \approx i,$

$$C_B = (1 + m_B^{fract})\,\{0.17\,\mathrm{Cos}[\mathrm{ArcTan}(i)] + 39.20\,\mathrm{Sin}[\mathrm{ArcTan}(i)]\}$$

Superficie
(peggioramento?)

pista vs. treadmill
(marcia)


ABSTRACT

The energy consumption of walking relates to the intensity of physical effort and can be affected by the alterations in walking speed. Therefore, walking speed can be accepted as a crucial, determinant of energy consumption measurement for a walking test. We aimed to investigate the differences in preferred walking speed (PWS) determined both on overground and on a treadmill and, to measure walking energy expenditure and spatio-temporal parameters of gait on a treadmill at both, speeds. Participants ($n = 26$) walked on a treadmill at two pre-determined speeds for 7 min while, indirect calorimetry measurements were being performed. Spatio-temporal parameters were collected, by video-taping during each walking session on a treadmill. The average overground preferred walking
1.43 ± .21 speed (O-PWS) was 85.96 ± 12.82 m/min and the average treadmill preferred walking speed (T-PWS), was
1.19 ± .23 71.15 ± 13.85 m/min. Although T-PWS was lower, oxygen cost was statistically higher when, treadmill
3.30 ± .42 walking at T-PWS (0.158 ± 0.02 ml/kg/m) than when the treadmill walking at O-PWS, (0.1480 ± 0.02 ml/kg/ 3.09 ± .42
m). Cadence (127 ± 9.13 steps/min), stride (134.02 ± 14.09 cm) and step length (67.02 ± 6.90 cm) on the treadmill walking at O-PWS were significantly higher than cadence (119 ± 10 steps/min), stride (117.96 ± 14.38 cm) and step length (59.13 ± 7.02 cm) on the treadmill walking at TPWS. In conclusion, walking on treadmill using O-PWS is more efficient than walking on treadmill using TPWS, in walking tests. Since using T-PWS for treadmill walking tests overestimates the oxygen cost of walking, O-PWS should be used for oxygen consumption measurement during treadmill walking tests.

## Superficie
(peggioramento?)

## pista vs. treadmill
(marcia e corsa)

| VARIABLE | TREADMILL LOCOMOTION | OVER-GROUND LOCOMOTION |
|---|---|---|
| **Stance phase** | < | > |
| **Cadence** | + 7% in adults<br>+ 10% in children 6 - 7 years | < |
| **Length stride cycle** | < | > |
| **Propulsion phase** | > | < |
| **Hip and knee flexion** | > | < |
| **Pelvic oscillation** | < | > |

Superficie
(peggioramento?)

pista vs. treadmill
(marcia)

Velocità

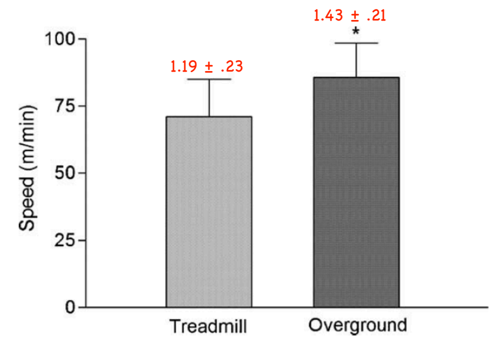



**Fig. 1.** Means and standard deviations of walking speeds determined on both a treadmill and overground.

## Superficie
(peggioramento?)

pista vs. treadmill
(marcia)

$\dot{V}_{O2}$

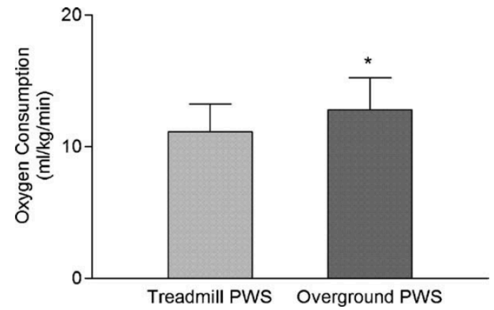



**Fig. 2.** Means and standard deviations of oxygen consumption during walking on a treadmill with speeds determined both on a treadmill and overground. PWS, preferred walking speed.

## Superficie
(peggioramento?)

pista vs. treadmill
(marcia)

C*

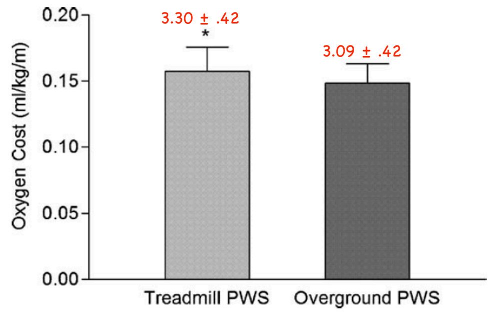



**Fig. 3.** Means and standard deviations of oxygen cost during walking on a treadmill with speeds determined on both a treadmill and overground. PWS, preferred walking speed.

Superficie
(peggioramento?)

pista vs. treadmill
(marcia)

$C^*$ vs. Velocità

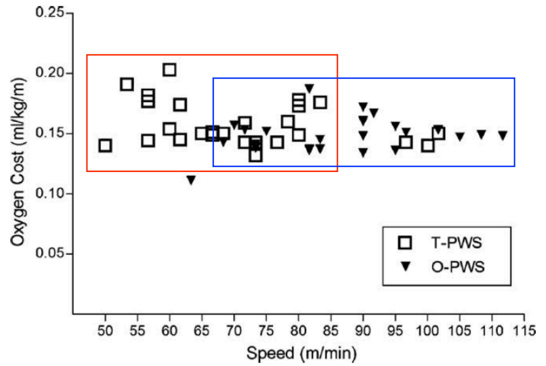



**Fig. 4.** The oxygen cost of T-PWS and O-PWS of treadmill walking versus the preferred walking speeds of subjects. T-PWS, treadmill preferred walking speed; O-PWS, overground preferred walking speed.

# Superficie
## (peggioramento?)

## pista vs. treadmill
(marcia)

**Table 1**
List of parameters during walking on a treadmill at the overground and treadmill preferred speeds.

| | Treadmill mean ± SD | Overground mean ± SD | Significance |
|---|---|---|---|
| Speed (m/min) | 71.15 ± 13.85 | 85.96 ± 12.82 | $P < 0.05$ |
| Oxygen consumption (ml/kg/min) | 11.15 ± 2.11 | 12.80 ± 2.46 | $P < 0.05$ |
| Oxygen cost (ml/kg/m) | 0.158 ± 0.02 | 0.148 ± 0.02 | $P < 0.05$ |
| Cadence reached (steps/min) | 119.06 ± 10.35 | 127.25 ± 9.13 | $P < 0.05$ |
| Step length (cm) | 59.13 ± 7.018 | 67.02 ± 6.90 | $P < 0.05$ |
| Stride length (cm) | 117.96 ± 14.38 | 134.02 ± 14.09 | $P < 0.05$ |
| RER | 0.824 ± 0.065 | 0.837 ± 0.064 | $P > 0.05$ |

RER, respiratory exchange ratio; SD, standard deviation.

3.18 vs. 2.99

Superficie

(peggioramento?)

pista vs. treadmill

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# OXYGEN INTAKE IN TRACK AND TREADMILL RUNNING WITH OBSERVATIONS ON THE EFFECT OF AIR RESISTANCE

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(*Received 8 December 1969*)

## SUMMARY

1. The relation of $\dot{V}_{O_2}$ and speed was measured on seven athletes running on a cinder track and an all-weather track. The results were compared with similar observations on four athletes running on a treadmill.

2. In treadmill running the relation was linear and the zero intercept coincided with resting $\dot{V}_{O_2}$.

3. In track running the relation was curvilinear, but was adequately represented by a linear regression over a range of speeds extending from 8·0 km/hr (2·2 m/sec) to 21·5 km/hr (6·0 m/sec). The slope of this line was substantially steeper than the regression line slope for treadmill running.

4. The influence of air resistance in running was estimated from measurements of $\dot{V}_{O_2}$ on a subject running on a treadmill at constant speed against wind of varying velocity.

5. The extra $O_2$ intake ($\Delta\dot{V}_{O_2}$) associated with wind increased as the square of wind velocity. If wind velocity and running velocity are equal, as in running on a track in calm air, $\Delta\dot{V}_{O_2}$ will increase as the cube of velocity.

6. It was estimated that the energy cost of overcoming air resistance in track running is about 8% of total energy cost at 21·5 km/hr (5000 m races) and 16% for sprinting 100 m in 10·0 sec.

## INTRODUCTION

The first detailed study of the relation of oxygen consumption and speed in running was that of Sargent (1926). Sargent solved the difficulties associated with the bag method by having his subjects run 120 yd. holding their breath. Expired gas was collected for 40 min after running, and the resting supine $O_2$ intake was deducted from the total $O_2$ intake to give the $O_2$ consumption, and hence the energy requirement of the work. The results seemed to show that the $O_2$ consumption in l./min increased as the

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Mezzo (aria)

corsa

v vs. distanza (quota vs. l.d.m.)

**Table 3.** Results of athletic events at the Olympic Games, Mexico City, 1968, compared with existing world records (October 1968) and record times at sea-level (National Union of Track Statisticians)

| Distance (m) | Olympic finals (min | sec) | World record (min | sec) | Sea-level best performance (min | sec) | % differences from sea-level best performance |
|---|---|---|---|---|---|---|---|
| 100 | | 9·9 | | 9·9 | | 10·0 | +1·0 |
| 200 | | 19·8 | | 19·7 | | 20·0 | +1·0 |
| 400 | | 43·8 | | 43·8 | | 44·5 | +1·6 |
| 800 | 1 | 44·3 | 1 | 44·3 | 1 | 44·3 | 0 |
| 1,500 | 3 | 34·9 | 3 | 33·1 | 3 | 33·1 | −0·8 |
| 5,000 | 14 | 05·0 | 13 | 16·6 | 13 | 16·6 | −6·1 |
| 10,000 | 29 | 27·4 | 27 | 39·4 | 27 | 39·4 | −6·5 |

# Mezzo
## (aria)
(pista, l. m.)

corsa

$\dot{V}_{O2}$ vs. velocità

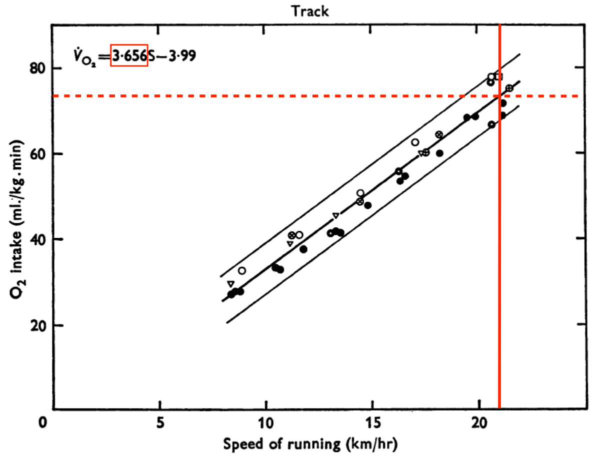


Fig. 1. Relation between $O_2$ intake and running speed on a cinder track and an all-weather track. 95% confidence limits are shown. Subjects were: ⊙ B. T., ◎ G. N., ⊗ M. H., ⊕ C. S., ⊗ M. T. (cinder track) and ● B. T., ○ G. N., ▽ J. T., □ T. J. (all-weather track).

# Mezzo
## (aria)
(treadmill, 'l. m.')

corsa

$\dot{V}O_2$ vs. velocità

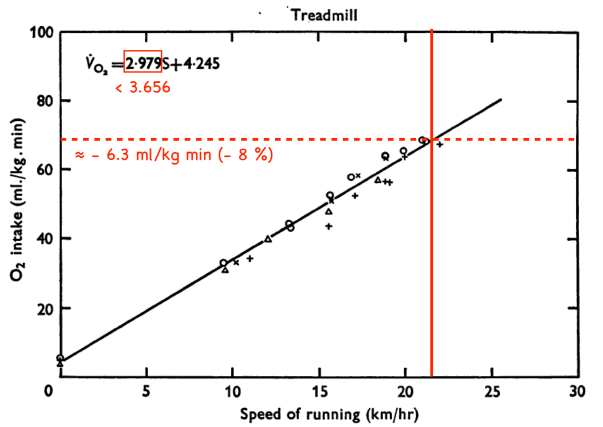


Fig. 2. Relation between $O_2$ intake and speed for athletes running on a treadmill. Subjects were: × M. T., ○, R. H., + T. J. and △ C. F.

# Mezzo
(aria)

corsa

$\dot{V}_{O2}$ vs. velocità

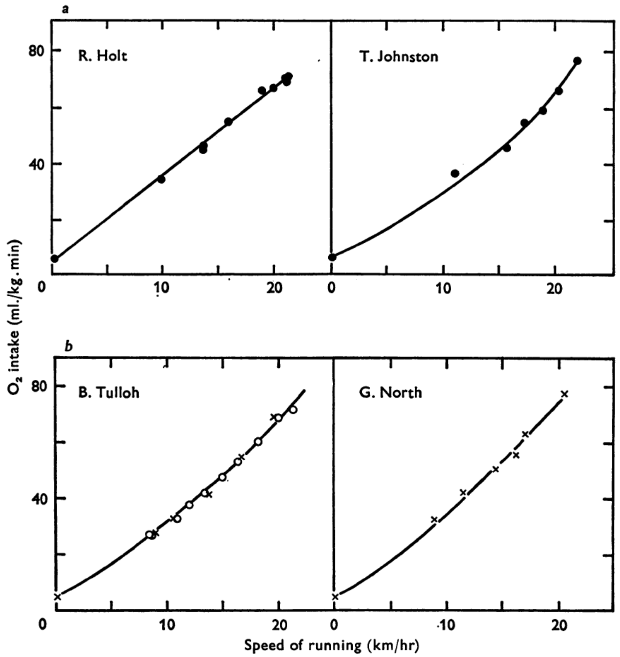


Fig. 3. Relation of $O_2$ intake and speed in individual athletes (*a*) on the treadmill, and (*b*) on the track (B. Tulloh, × with shoes and ○ without shoes). The curves have been extrapolated to resting $O_2$ intake.

+ .5 kg!!

# Mezzo
(aria)

corsa

area frontale

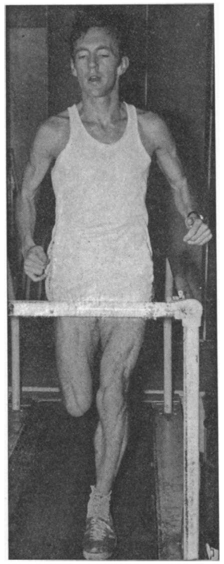

Fig. 4. Photograph from which the athlete's projected area was determined in the experiment on the effects of air resistance. The reference surface of known area has been omitted.

Effetto del vento

.478 m²* .478/1.8 = .266 66.1 kg

# Mezzo
## (aria)
(treadmill, 'l. m.')

corsa

$\dot{V}_{O2}$ vs. $v_{vento}^2$

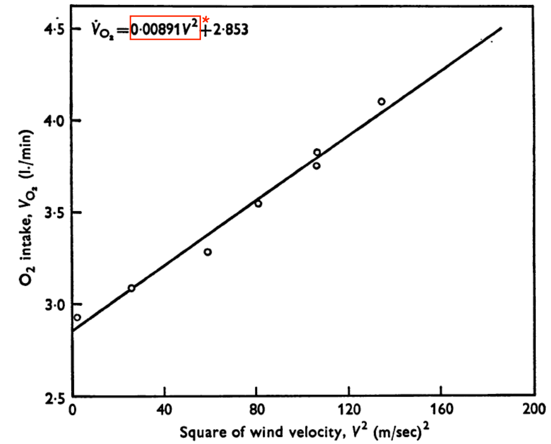


Fig. 5. $O_2$ intake plotted against the square of wind velocity for M. Turner* running at 15·9 km/hr (4·42* m/sec) against wind of varying velocity.

# Mezzo
## (aria)
(pista, l. m.)

Resistenza aerodinamica in pista

$d\dot{V}_{O2} = aFS$

$F = bV^2$

$d\dot{V}_{O2} = abSV^2$ (eq. 4)

$(d\dot{V}_{O2} = )\ abSV^2 = .0089V^{2*} = .002V^{3*}$
(aria calma)

$ab = .0089/4.42 = .00201^*$

$d\dot{V}_{O2} = (A_p/.478).002V^3 = .00418A_pV^3$

$d\dot{V}_{O2} = .436 \times .00418(6.0)^3 = .394$ l/min -> 6.4 ml/kg min (≈6.3)
(61.3 kg)

## Disponibili tirocini, tesi triennale e specialistica (1: 5)

- Recupero corsa in avanti vs. corsa all'indietro;
- bioenergetica della corsa prolungata in pista e su treadmill;
- bioenergetica & biomeccanica della corsa prolungata (MF);
- bioenergetica & biomeccanica dell'in-line skating (MpF);
- bioenergetica & biomeccanica dell'handbiking (PhD p);

## Disponibili tirocini, tesi triennale e magistrale (2: 6)

- bioenergetica & biomeccanica dell'handbiking dopo RMET (PhD p);
- bioenergetica & biomeccanica dell'handbiking dopo HIT (PhD p);
- bioenergetica & biomeccanica dopo long bed rest (MF);
- bioenergetica & biomeccanica del nordic running;
- bioenergetica & biomeccanica di vari trekking (MF);
- costo metabolico marcia, corsa, ciclismo e sci di fondo stessi soggetti;

## Disponibili tirocini, tesi triennale e magistrale (3: 5)

- costo EMG della marcia (MF);

- frequenza di skipping e costo metabolico della corsa (MpF);

- review dei sistemi di misura portatili dell'attività fisica e del dispendio metabolico (C);

- salto in lungo da fermo con masse aggiunte ed allenamento;

- bioenergetica e biomeccanica della regata velica.