Energy cost of mountain snow-shoeing
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Introduction
Walking on snow, (also called snowshoeing), across mountain open spaces or arranged tracks, could be considered a natural way to practise trekking activity in winter seasons. Our previous study (Leonardi et al., 2004) showed strong relationships between energy expenditure and speeds of walking on recurrent kinds of terrain (gravel Vs. rock-wood steps) at different slopes. The aim of this preliminary study is to prosecute, with modern technologies, the measure of the metabolic requirement on different snows type (untouched Vs. packed by snowcat) walking without pales at comfortable self selected speeds for different uphill and downhill gradients.

Methods
Topographical surveys were executed on mountain area (Italian pre-Alps, Lessinia-MonteBaldo) between 1300 - 1800 m altitude to detect single units at different slopes on free mountain space (untouched snow) and on ski-area tracks (packed snow). Each unit was digitalised by using cartographic imaging 3D with positioning satellite receiver GPS (Garmin 76S, USA with barometric altitude correction). Tests were executed, on five volunteers (M, 28.2 ± 2.6 [yrs], 71 ± 12.5 [kg], 179.2 ± 6.1[cm], 22 ± 2.5 BMI) instrumented with a portable gas analyzer (K4b2, COSMED, Italy), GPS and hart rate monitor (Polar, Finland) integrated modules. The average values, late in the winter season, of air temperature and umidity were 13.3 ± 2.2 [°]; 42 ± 8.3 [%] for the packed snow and 9.2 ± 5.3 [°]; 42 ± 5.9 [%] for untouched snow. The maximum dept of the snow without new accumulations was respectively 26; 43 [cm], whereas the average depthe depressions of the snowshoes was 2.8 ± 1 [cm]; 7.3 ± 3.2 [cm]. Subjects walked along selected units with gradient between +/- 30 [%] and used snowshoes (TSL Rando, France) weight 1.8 [Kg] per pair (63 x 23 cm each one) only in free-rolling mode. Three speeds from 1.3 to 8.5 [Km·h⁻¹] were self selected on the basis of personal physical capacity in order to have habitual, lower and higher sense of effort. Energy cost (CE) of walking was calculated for each test from the steady state V'O₂ using heart rate and ventilation data to check the sub-threshold level of effort. In this condition CE was set equal to the average value of oxygen net consumption per body mass ratio to average chronometric speed on covered path. CE [J·kg⁻¹·m⁻¹] = V'O₂ net [ml·min⁻¹·kg⁻¹]/velocity [m·min⁻¹]

Results
In snowshoeing test we observed similar behaviour of CE/gradient and speed/gradient functions as well as in previous trekking energy cost study. The CE/gradient function were described by III° order polynomial with the absolute minimum of 2.2 [J/(Kg·m)] around –18 [%] at 3.2 [Km/h] on packed snow and 3.4 [J/(Kg·m)] around –23 [%] at 2.4 [Km/h] on untouched snow. The comparison between the two snows conditions showed a higer value of CE on unpacked snow ranging (0.6-1.4) [J/(Kg·m)] around slope from –25 to 20 [%]. The greatest speed for both snows was reached at –20 [%]. The average self selected speed resulted little faster (0.1-0.4) [Km/h] on packed snow for slopes from –30 to 12 [%], above them no statistical change was measured. Walking on the snow at gradients greater than –20 [%] causes a considerable CE increase ranging (1.1-2.6) [J/(Kg·m)] compared respectively, to trekking and (1.8-3.8) [J/(Kg·m)] to treadmill. The average self selected speed on snow was (0.6-1.7) [Km/h] lower compared to gravel terrain for all slopes and higher (0.2-1.2) [Km/h] compared to stony and rock steps terrain at extreme downhill slopes (below –20 [%]).

Discussion and Conclusion
Our data support the results of previous study obtained by hart rate frequency (Connolly, 2002), indeed snowshoeing requires a considerable amount of energy expenditure. In comparison to normal trekking activity is necessary an additional energy from +30 % to 70 %. On untouched snow, the CE increase depends on several situations, (deph depression of the snowshoes, loss of rhythmic rate, etc.) mainly caused by compactness grade. Walking efficiency is affected by snow types in relation to low and medium slopes, whereas at extreme slopes the advantage of snowshoeing on packed snow is not much high.

References
Connolly Declan A J (2002). The energy expenditure of snowshoeing in packed Vs. unpacked snow at low-level walking speeds, J. of Strength and Conditioning Research, 16(4): 606-610