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Topographical and physiological data collection for urban handbike tracks design

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ABSTRACT: Cities should guarantee, to all the citizens, spaces for physical activity to allow people to reach the correct amount of activity during the week. Physical activity areas for people with disability need specific safety and accessibility precautions. The aim of this study is to give suggestion to modify tracks suitable for handbike practice and to classify and describe them in order to give useful information to the users. Ten healthy subjects were tested on a dedicated handbike equipped with a powermeter. The oxygen consumption, heart rate, speed, track elevation profile and distance during the execution of one selected track were simultaneously detected. This experimental set up resulted a reliable tool to describe the relation between the track topographical features and the individual metabolic engagement as a function of the speed. Further measures, on subjects with motor disability, will be the crucial translational phase of the whole project.

1 INTRODUCTION/STATE OF THE ART

Physical activity improves physical fitness in all its components, mood and socialization (Barros et al. 2017; Donnelly et al. 2017; Ekelund et al. 2018). In particular, in a population with reduced mobility the execution of regular adapted physical activity (APA) can improve lifestyle quality, prevent the rising of non-communicable diseases and contribute to increase the expectancy of active life. Inaccessibility of structures or places for adapted physical activity practice must be overcome by institutional urban policy (Rimmer et al. 2004). Indeed, even the availability of tracks for hand-biking practice within urban areas is scarce. In particular, the identification of enjoyable tracks in green areas is lacking in most of the western cities.

According to the literature (CDC.GOV/disabilities/PA) the practice of APA needs both accessibility of the exercise/sport facilities and a tailored exercise prescription based on individual physical fitness in relation to the track characteristics. Currently, 57% of the adults with motor disability does not reach the recommended amount of aerobic physical activity.

Our group of research would contribute to face the above reported issues supporting the design of useful tracks in town for handbikers, mostly represented by persons with spinal cord injury.

2 OBJECTIVE OF THE PAPER

In this view this project is aimed to identify a method based on the simultaneous recording of ergometabolic, kinematic and topographical data in order to: 1. provide the Brescia municipality with useful and applicable suggestions to modify or adapt the already existing paths and make them suitable for handbike use; 2. classify the different tracks on the basis of the required external work and let the users choose the best pattern according to their fitness.

3 METHODOLOGICAL APPROACH AND/OR RESEARCH APPROACH

The first step of this project was the identification of the tracks suitable for handbike use; there are several places in Brescia where it is possible to cycle, but handbike needs tracks with peculiar features. First of all, the route should be easy to be reached by public transportation or by car, with dedicate parking lot. Then, the surface has to be regular, without big potholes or slippery surfaces ensuring a safe and efficient cycling. Handbikers need a lay-by zone where to rest without occluding the street and large enough to allow the change of direction. Finally, the tracks must not include dangerous parts both for the bikers and for the other people (for example pedestrian crossings or busy intersections).

Once identified the tracks (an example is reported in (Figure 1)) they will be studied according to their features such as the elevation profile, the surface and the requested ergometabolic engagement of the subject. Eventually, the following factors will be measured and reported:

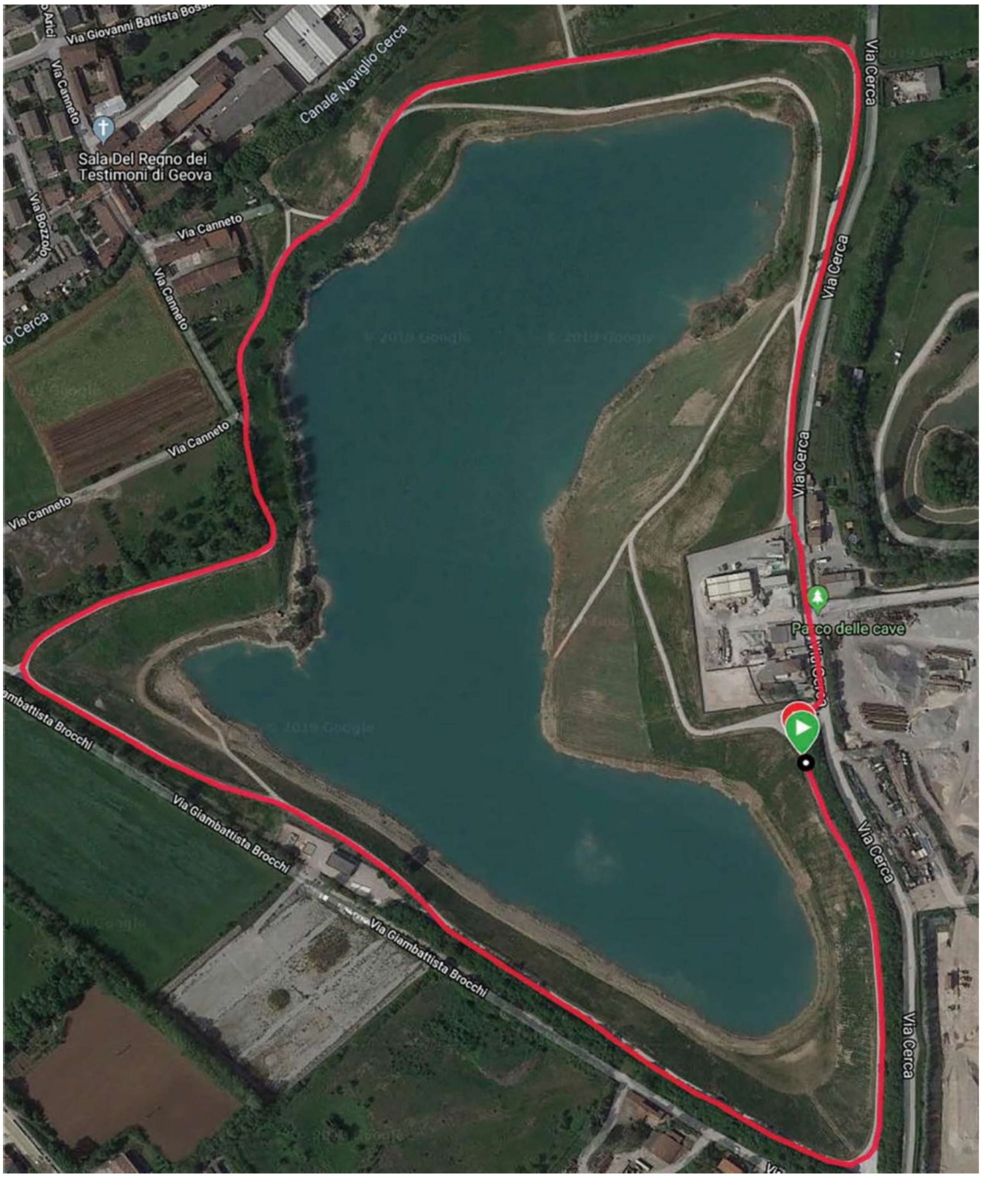

Figure 1. Example of track (red line) in a public and car free area.

altitude variation along the path with respect to the start height above the sea level, length and riding velocity using the GPS, the requested crank power as well as the cardio respiratory adaptations (HR, oxygen consumption for energy expenditure calculation). The instrumentation used in order to record the data is: 1. dedicated handbike (Maddiline) with a power-meter (powertap g3 rear disc hub) set on the wheel hub; 2. metabolimeter (K4b2 Cosmed); 3. Heart rate, GPS, speed and altitude monitor (Garmin Edge 510). Participants' advices and clues to improve the track path (e.g. to change the slope of the track), the accessibility (e.g. more dedicated parking lots or more public transportation facilities) and the safety (e.g. reroute the pedestrian crossing) will be also collected. The analysis of the tracks has been performed on specific segment of it, to reduce variability due to transient phases in the beginning and in the end of the exercise.

4 DESCRIPTION

4.1 *Innovative aspects*

The research has been developed within an interdisciplinary team (MOTUS Project granted by University of Brescia). In particular, the results hereby showed, refer to the urbanistic and physiological outcomes which combine the measurements and the characteristics of the track paths with the ergometabolic engagement of a handbiker.

With regard to the former aspects a study for handcyclable track around the historical city centre of Brescia was performed as it follows: 1. elements of foreknowledge (standards for cycling tracks, handbikes data, handbikers experiences), 2. detailed analysis of the urban context (presence of green areas and their possible connections and geometric characteristics of the each single part of the track and their possible connections), 3. study of existing and planned cycle routes (mainly it consists of four different kinds of tracks most of which are not suitable for handbikes), 4. project of the track around the historical city centre (the proposal route cannot be used for sport purposes, but only for touristic and leisure ones because of the multiple constraints given by the historical context) (Arenghi et al. 2018).

4.2 *Research and/or technical developments*

Suitable handcyclable routes can be designed for a proper use outside the historical city centre where the existing context allows to have the geometric and services conditions above mentioned. This could be a good opportunity for Brescia municipality, while designing the new urban park in the south of the city, to improve accessibility for users with disability through an inclusive action.

5 RESULT OF THE RESEARCH

The graph in (Figure 2) reports the mean trends of some of the parameters recorded during the test by 10 subjects in a portion of a single lap of an exemplificative track. The trend of force and heart rate is strongly affected by the elevation profile. In (Figure 2) are highlighted two particular segments of the track: the main downhill (grey rectangle) and the subsequent uphill (yellow rectangle). As expected, the HR decreases following the descent and force reaches near zero values. Vice versa, during the ascent the HR rising is clearly noticeable. Force rising occurs just few moments later, this is probably linked to inertia previously developed. The fluctuations in the remaining sections of the track comply with these assumptions.

The third figure (Figure 3) shows the linear correlation between speed recorded by the GPS and the metabolic equivalent of task (MET) (1MET= 3.5mlO_2/Kg/minute) calculated for every subject (blue spot) from direct measure of the oxygen expenditure using K4 device. The MET value refers to a single lap of the same track for every subject. It is clearly visible that the two variables (speed and MET) are directly correlated ($p<0.001$). Following WHO

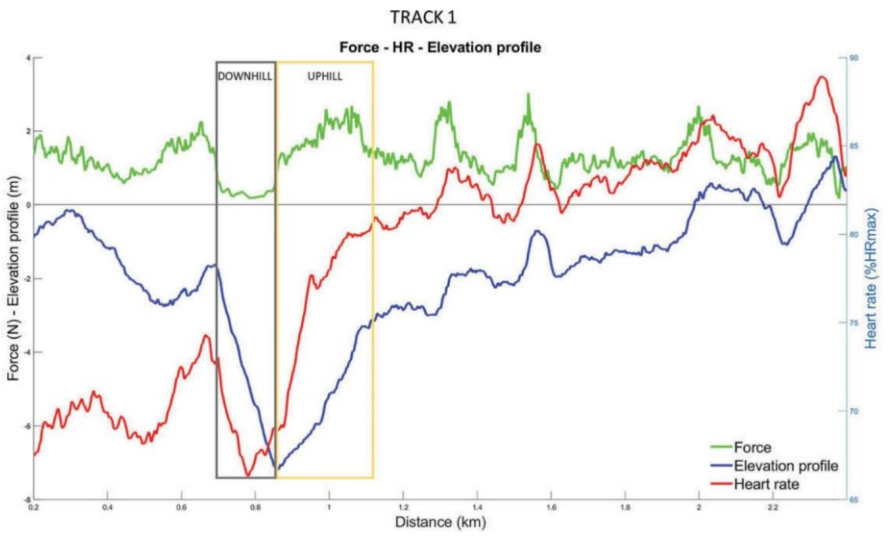

Figure 2. Elevation profile of the track and force applied to the cranks (left y axis) and heart rate (right y axis).

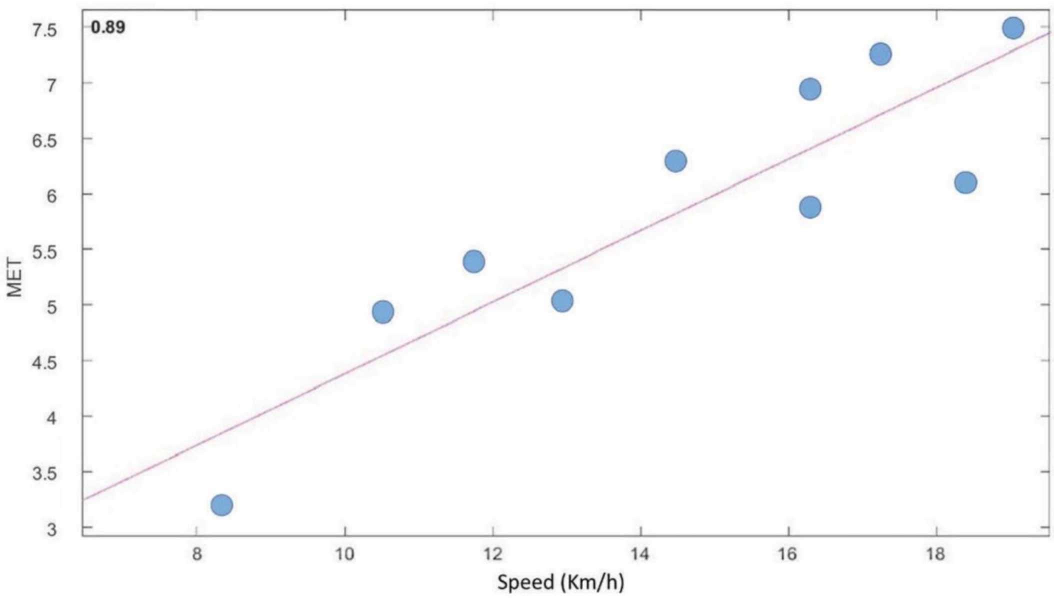

Figure 3. Correlation between speed and oxygen consumption standardised in MET.

recommendations (WHO 2010), to reach the correct amount of physical activity handbikers should cycle with an average speed between 7km/h and 15 km/h in order to perform moderate activity. Velocity over 15 km/h imply vigorous activity.

6 CONCLUSIONS

This project was aimed to sustain the local municipality to promote the practice of hand biking, in subjects with limited mobility, by targeted actions intended to make Brescia more accessible for adapted physical activity practice and to set a method for handbike tracks design and classification on the basis of the required effort. The tool described in this work could be considered for future institutional programs. The results of this pilot study in healthy subjects will provide a standard data-set to be compared with specific parameters obtained during hand-cycling in subjects with disability.

6.1 *Barriers and drivers*

In order to have handcyclable track paths, the Italian historical city centres are not suitable.

REFERENCES

Arenghi A., Piona M., Rosseti S., Tiboni M. (2018) Città e benessere: Pianificare e progettare lo spazio urbano secondo i principi di healthy city e active design in AA. VV. (2019), Atti della XXI Conferenza Nazionale SIU. CONFINI, MOVIMENTI, LUOGHI. Politiche e progetti per città e territori in transizione, Firenze 6-8 giugno 2018, Planum Publisher, Roma-Milano.

Barros RM, Silver EJ, Stein REK, et al (2017) The Association Between School-Based Physical Activity, Including Physical Education, and Academic Performance. J Sch Health 80:517–526. doi: 10.1542/peds.2007-2825

Donnelly JE, Ed D, Co-chair F, et al (2017) Physical activity, fitness, cognitive function, and academic achievement in children: A systematic review.

Ekelund U, Brown WJ, Steene-Johannessen J, et al (2018) Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants. Br J Sports Med 1–9. doi: 10.1136/bjsports-2017-098963.

Rimmer JH, Riley B, Wang E, et al (2004) Physical activity participation among persons with disabilities: Barriers and facilitators. Am J Prev Med 26:419–425. doi: 10.1016/j.amepre.2004.02.002.

WHO (2010) Global recommendations on physical activity for health. World Health Organization.