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Handbike Riding in the Brescia Urban Loose Space: Topographical Evaluation and Metabolic Demand Estimation of Four Suitable Tracks

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Abstract: This study examines four tracks (Ts) suitable for handbikes (HBs) in the urban area of Brescia, Italy. WHO physical activity (PA) recommendations challenge kinesiologists to find opportunities to promote exercise in the urban context using HBs. This study aims to characterize T features, assess the physical demands of HB cycling, and promote the use of HBs. Track length, elevation changes, slope, and ascent sections were analyzed. Participants' physiological engagement during HB cycling was measured. The data were gathered using specialized equipment including a metabolimeter, a power meter, a heart rate monitor, and a cycle computer. Crucially, the findings demonstrate that all four Ts facilitate PA above the recommended threshold (>3 MET) regardless of the speed. The study identifies specific speeds required to achieve vigorous PA (>6 MET) on each T. In summary, this study's analysis of various tracks reveals their potential to meet PA guidelines, even at a slow pace. Moreover, this research establishes speed thresholds for vigorous PA. This information is valuable for both able-bodied individuals and those with mobility challenges when planning effective exercise routines. Moreover, the findings support municipalities in promoting adapted PA in urban areas, enhancing path usability.

Keywords: handbike; physical activity; urban space; active city; adapted exercise; inclusive sport

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1. Introduction

Nowadays, physical activity (PA) is known to be a key factor in weight control [1,2] and in the prevention of non-communicable diseases (e.g., cancer, mellitus diabetes, cardiovascular, and pulmonary affections), which are responsible for 41 million deaths per year [3,4]. Furthermore, physical inactivity is the fourth leading risk factor for premature death with 2 million deaths per year [5,6]. In 2020, the World Health Organization (WHO) updated the PA and sedentary behavior guidelines [7]. It is well known that the recommended PA amount, for healthy adults and elderly people, should be at least 150 or 75 min/week at a moderate (a $\geq$3 and <6 metabolic equivalent of the task (MET)) or vigorous ($\geq$6 MET) intensity, respectively [7–9]. This may provide health benefits and include subjects in the active population to avoid the previous indicated negative outcome of inactivity. Daily life PA activities are crucial to achieving these recommendations to maximize their outcome on individual aerobic capacity (with the correlated positive effects on global health), and exercise should be regularly scheduled throughout the week [10,11].

However, sometimes, common daily life activities, such as going to work, making the groceries, etc., are made possible only with the aid of public transport or, most of the time, private motorized vehicles, influencing both air pollution and overall health. Active transport modes, such as walking or cycling, offer numerous benefits to health and the environment by increasing physical activity levels, reducing pollution, and easing congestion. They contribute significantly to the global sustainable development goals by addressing air pollution, ensuring sustainable urban transport, and fostering multiple societal improvements [12]. Although these modes positively impact human health by reducing chronic diseases and mortality rates, a considerable portion of adults fail to meet recommended physical activity levels. Promoting walking or cycling becomes crucial, not only for health but also for reducing carbon emissions, aligning with global sustainability initiatives. The integration of these modes into policies like the European Green Deal highlights their importance [13,14]. The exploration of new strategies in the context of active transport remains essential for understanding and promoting behavioral change towards adopting these modes for improved health and environmental outcomes.

The decline in autonomous movement and sustainable transportation usage may stem from environmental characteristics or from temporary or permanent alterations in motor control. These factors may drastically reduce the time spent in both unstructured and structured daily PA. For this reason, it is necessary to identify places suitable for increasing both the amount and the intensity of structured PA. Some sport-related activities may be undertaken in tight spaces [15], such as in gyms or sport pitches, while other activities such as running, cycling, or hand-cycling can be practiced on public loose spaces [15] such as parks and streets, while daily PA is manly connected to the use of public spaces.

To achieve the recommended weekly PA levels and intensities, various muscle-engaging, low-impact means of transportation could be utilized. Among these options, the handbike (HB) stands as an extremely versatile tool for engaging in PA either individually or within a group setting, and whether on streets or designated tracks. HB cycling allows one to increase cardiovascular fitness and upper body muscular fitness, easily achieving moderate to vigorous PA intensity [16]. Moreover, engaging in PA through HBs offers numerous advantages from various perspectives. The design of the three-wheeled HB ensures safety, particularly for individuals with compromised balance and motor control, such as the elderly [17–20]. Furthermore, it fosters inclusivity by enabling individuals with specific residual abilities to actively participate in PA. However, in contrast to many other adapted forms of PA, engaging in HB practice allows for the attainment of higher cardiovascular training capacities, leading to a notably more significant impact on overall health [21,22]. Moreover, the outdoor practice of PA through HB cycling increases the duration of moderate to vigorous PA, surpassing that of indoor PA sessions [23]. This extended engagement with outdoor PA exerts a positive influence on mental and psychological well-being [24,25]. In general, the use of HB for PA practice may be a valuable component of an overall strategy aimed at reducing the share of the population prone to inactivity syndrome, concurring with the sustainability of the health care expenditure of the welfare system [26,27].

Although several studies have investigated HB use benefits for individuals with disabilities [21,28], the authors acknowledge the lack of studies, not only in people with disabilities, characterizing in depth ergometabolic response during HB cycling along outdoor paths when their topography is considered. In this context, the characterization of the metabolic response along selected tracks could provide valuable information to individuals who want to practice HB in the selection of a more suitable place for outdoor PA.

This study focused on HB tracks in the Italian city of Brescia, a city located in the Lombardy region of Italy, with a population of approximately 200,000 people. We hypothesize that analyzing the topographical features of specific HB tracks in Brescia, along with their mechanical power requirements and ergometabolic demands will offer valuable insights into the accessibility and usability of urban environments for individuals who want to practice HB.

On these bases, the aims of this work are as follows: (1) to describe the topographical characteristics of four tracks suitable for HB in the urban area of the Italian city of Brescia;

(2) to evaluate ergometabolic and power engagement during hand biking along these tracks; (3) to promote PA through the use of a safe and sustainable means of transportation on selected tracks, considering pathway functional requirements and individuals' physical capacities.

2. Materials and Methods

2.1. Subject Enrollment and Track Description

The study examined four HB-suitable, public and free-to-use tracks located in the municipality of Brescia (Figure 1), including the following: Track 1 Canneto Lake (address: via Canneto, Brescia; 45.504655435983416 DD, 10.26918868194747 DD) (T1), located 5.1 km from the city center in the San Polo neighborhood; Track 2 Bose Lake (address: via Bose, Brescia; 45.491653280838946 DD, 10.265773772402312 DD) (T2), located 6.3 km from the city center in the Buffalora neighborhood; Track 3 Abba-Tartaglia Sport Center (address: via Tirandi, Brescia; 45.56165905489333 DD, 10.21655461355865 DD) (T3), located 2.3 km from the city center in the San Bartolomeo neighborhood; and Track 4 (a section of the Mella river cycle path from via Oberdan to via Capretti; 45.561383 DD, 10.207086 DD) (T4), located 2.4 km from the city center in the Urago Mella neighborhood.

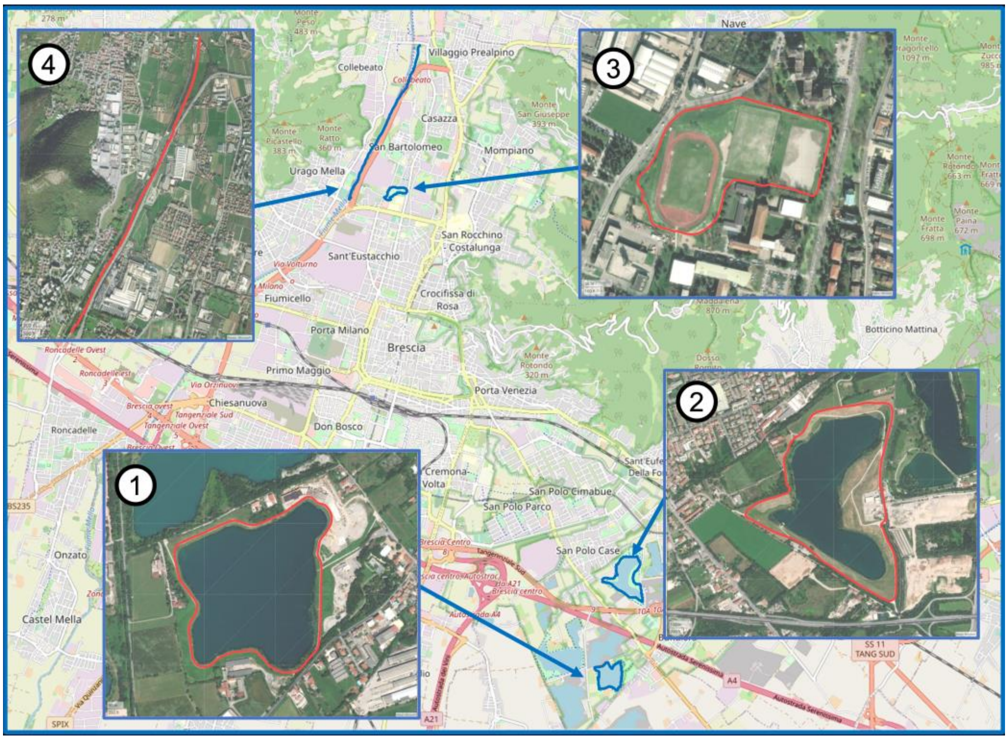

Figure 1. Location of the 4 tracks suitable for hand biking on the Brescia municipality map (the tracks are reported using blue lines). The four insets highlight the paths with a red line. The number of the track is reported in the circle located in the upper left corner of the image.

Brescia town Hall Palazzo Loggia, Piazza della Loggia 1, was considered the reference point for the "city center". To clarify the position of the tracks in the territory of Brescia, see Figure 1. Young adult participants without disabilities were divided aleatorily into 4 groups of 10 people based on the track they rode. For each track, the sample size of the participants was estimated using G*Power 3.1.9.7 for a correlation; bivariate normal model and input variables (tails = 2, correlation p H1 = 0.80, alpha = 0.05, power = 0.80) were estimated. The estimated minimum sample size was 9.

T1 included 9 males and 1 female, aged 24 $\pm$ 2, with a weight of 66 $\pm$ 8 kg and a height of 174 $\pm$ 5 cm, as well as a BMI of 22 $\pm$ 2 kg$\cdot$m^{-2}. T2 included 8 males and 2 females, aged 24 $\pm$ 2, with a weight of 68 $\pm$ 10 kg, a height of 173 $\pm$ 6 cm, and a BMI of 23 $\pm$ 2 kg$\cdot$m^{-2}. T3 included 7 males and 3 females, aged 24 $\pm$ 2, with a weight of 66 $\pm$ 9 kg, a height of

175 ± 5 cm, and a BMI of 21 ± 2 $kg \cdot m^{-2}$. T4 included 9 males and 1 female, aged 25 ± 2, with a weight of 67 ± 6 kg, a height of 175 ± 4 cm, and a BMI of 22 ± 1 $kg \cdot m^{-2}$. All participants provided informed consent prior to participating in the study, which was approved by the local Ethical Research Committee (CEIOC authorization: NP5286) in accordance with the Declaration of Helsinki (2004).

2.2. Study Design

Initially, the subjects were informed about the experimental procedure and subsequently instrumented (Figure 2). The subject wore a chest strap for the heart rate (HR) monitor (HRM-TriTM, Garmin, Olathe, KS, USA), which was moistened with water, applied directly on the skin, and positioned just below the sternum. After that, the subject wore a mask to monitor the gas exchange (O_2 and CO_2) with the ambient air. The breath-by-breath VO_2 consumption and the related MET value were provided by the K4 output dataset exported from the dedicated software (K4b2 v10, Cosmed, Agrate Brianza, MB, Italy). The metabolimeter (K4b2, Cosmed, Agrate Brianza, MB, Italy) was applied on the chest and its battery was applied on the back with a dedicated harness. A power meter (Powertap G3 Rear Disc Hub, Madison, WI, USA) was applied on the anterior wheel hub of the dedicated HB (Maddiline Cycle Snc, Verona, Italy) to evaluate the power and cadence of the cycling. HR, GPS data, power, cadence, speed and altitude were monitored and recorded throughout the cycle computer Garmin Edge 510 Monitor (Garmin, Olathe, KS, USA). The subjects were instructed to warm up, cycling for 10 min, in the area surrounding the starting point, at a slow velocity. Then, the participants were allowed to rest for at least 3 min to prevent fatigue from affecting neuromuscular activation [29]. Finally, the subject was asked to complete a full lap of the track at a self-selected speed and gear ratio. The reliability of the experimental design was assessed in a prior study [30].

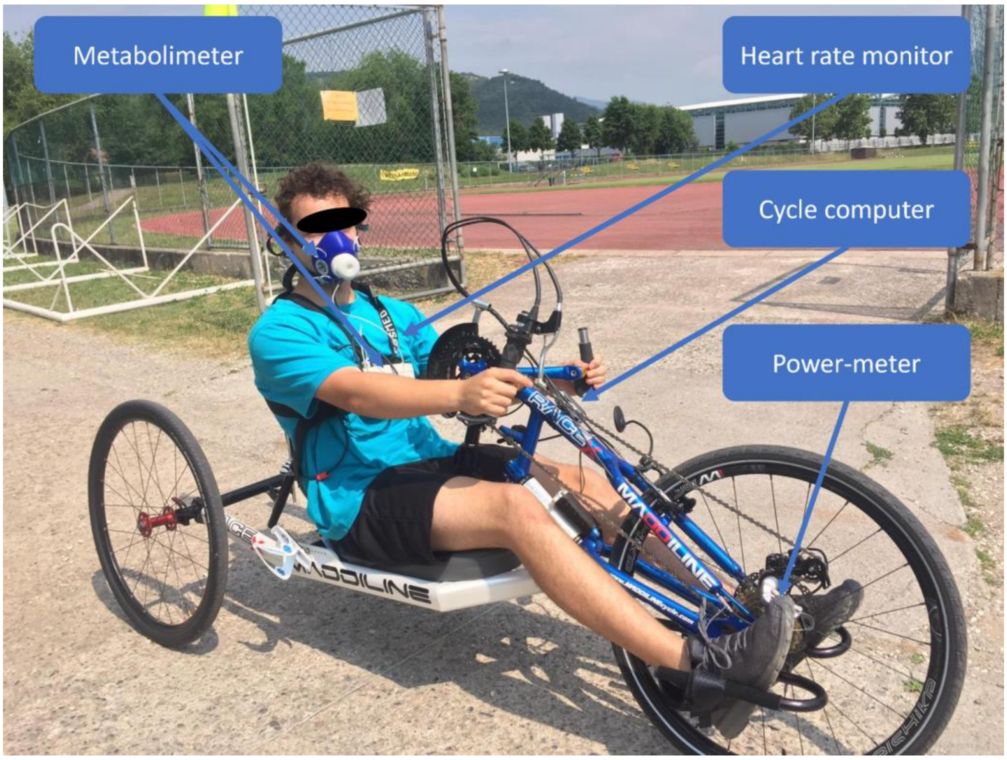

Figure 2. The sensorized HB used in this experiment, with a participant seated on the HB and instrumented before a test. Blue arrows indicate the position of the sensors used.

2.3. Metabolimeter Calibration and Sanitation

Before each test, the metabolimeter underwent a series of calibrations for the volume and the CO_2 and VO_2 relative fractions of the analyzed expired gas. Calibration was carried out, first providing the metabolimeter with a known volume of air from a 3l syringe and later sampling a known gas mixture with the following composition: O_2 = 16%, CO_2 = 5%, and N_2 = 79%. Following each test, the mask, turbine, harness, and head cap were thoroughly cleaned using water and a detergent solution containing chlorhexidine. Additionally, the sampling line was replaced and dried.

2.4. Data Analysis

The metabolimeter and HR monitor measured the individual VO_2 breath by breath and beat by beat, respectively. For this reason, to obtain a single dataset with a sample for each meter, data collected by the two systems were synchronized by means of common square wave markers. In Figure 3, the outcome of the procedure is shown. The overall characterization of the four tracks was made via averaging during exertion from the start to the end of hand biking in each subject, and is as follows: VO_2, HR, MET, speed, and power. The average group data were also calculated. The HR values were normalized to the subject's maximal HR identified through the Tanaka formula [31]. In order to comprehensively depict the inherent features of the tracks, we specifically identified the segments corresponding to the ascents. Subsequently, the dataset pertaining to these segments was extracted and analyzed separately. The ascents were characterized by the length, elevation gain, and slope. Subsequently, the mean power, peak power, mean speed, and mean cadence during the ascent effort were calculated based on the mean values and standard deviations derived from the subjects that performed the track. Only ascents with a slope steeper than 1%, length greater than 50 m and mean power higher than the mean power of the whole track were considered. To synchronize the VO_2 and HR dynamics, we used the GPS data to identify the meter-by-meter time at which the corresponding oxygen consumption and HR values were calculated from the stored VO_2 and HR time series.

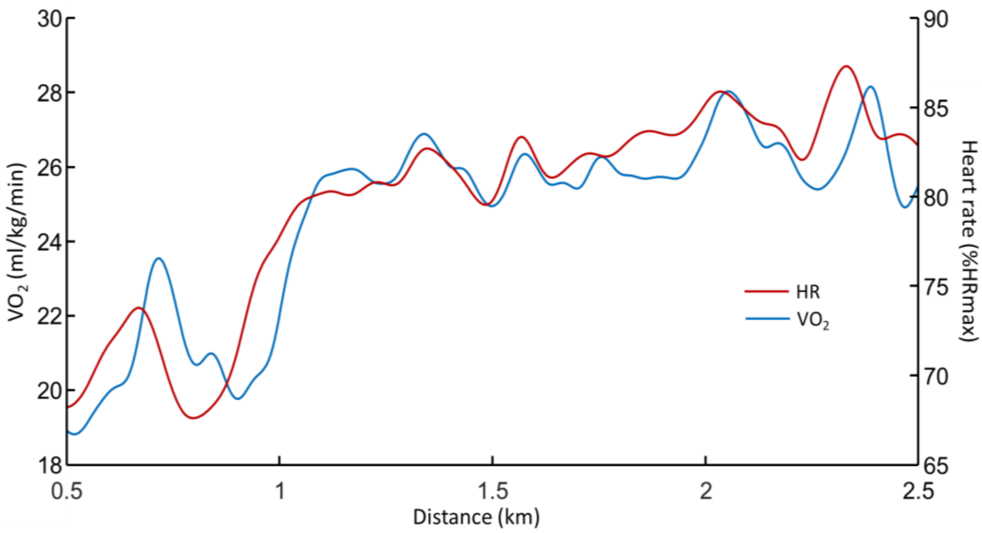

Figure 3. An example of VO_2 (blue line, left *y*-axis) and HR (red line, right *y*-axis) signals synchronized meter by meter.

2.5. Statistical Analysis

All results are expressed as mean and standard deviation unless otherwise stated. All variables were tested for normality using the Shapiro–Wilk test. The assumption of sphericity was checked using the Mauchly test, and if violated, the Greenhouse–Geisser correction was made to the degrees of freedom. Statistical significance was set at $p < 0.05$. Cross-correlation between MET and speed and between speed and power were calculated using Pearson's correlation coefficients between the pairs of variables. The G Power was set as 0.90.

3. Results

3.1. Track Topographical Characteristics and Specific Ergometabolic Demand

Track 1: the pavement is in gravel, the start is located 124 m above sea level (masl), and its length is 2.57 km, with an elevation gain of 8.4 m. The subjects, on average, performed on the track at 16.0 ± 2.2 km/h with a mean HR of 148 ± 25 bpm and 77 ± 8 $\%HR_{max}$, and a mean VO_2 of 23 ± 5 mL/kg/min, while the mean MET was 6.6 ± 1.5 and the mean output power was 69.48 ± 25.08 W. The track is characterized by five ascents, reported in Figure 4, the features of which are listed in Table 1. Ascent 5 has the higher slope (1.6%) while the peak power was recorded in ascent 1 (162.43 ± 53.12 W).

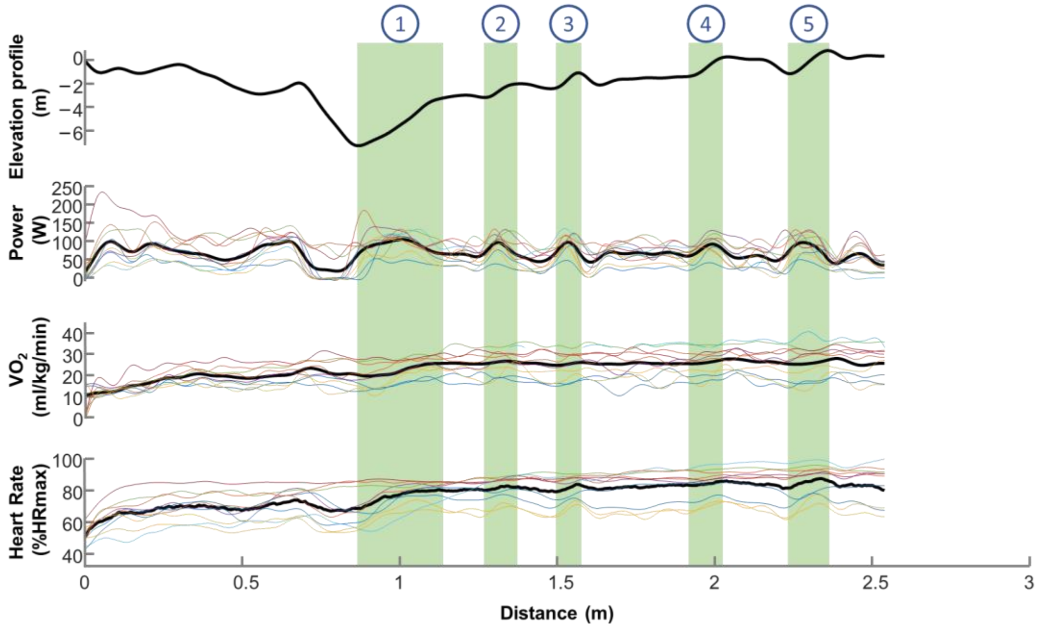

Figure 4. The elevation profile of T1 is shown in the upper panel. The numbers indicate the 5 ascents along the path. Mean signals of power, VO_2/kg, and HR for the participants are reported in black while each color refers to a single subject.

Table 1. For each identified ascent in each track, the average and standard deviation of the power, peak power, speed, and cadence of the subjects were calculated and reported. The characteristics of the ascent, such as length, elevation gain, and slope, are presented in the last three columns.

		Mean Power (W)	Peak Power (W)	Mean Speed (Km/h)	Mean Cadence (RPM)	Length (m)	Elevation Gain (m)	Slope (%)
Track 1	ASCENT 1	84.45 ± 15.75	162.43 ± 53.12	14.51 ± 2.88	48.90 ± 6	341	4.29	1.26
	ASCENT 2	81.90 ± 17.87	141.90 ± 42.96	12.58 ± 1.34	48.20 ± 8	109	1.17	1.07
	ASCENT 3	83.94 ± 19.67	153.34 ± 22.96	13.90 ± 1.44	44.86 ± 5	88	1.34	1.53
	ASCENT 4	79.79 ± 11.96	127.10 ± 33.78	12.71 ± 1.61	45.17 ± 4	126	1.65	1.31
	ASCENT 5	87.09 ± 9.33	136.79 ± 29.49	15.25 ± 2.26	52.13 ± 2	122	1.95	1.60
Track 2	ASCENT 1	119.24 ± 29.79	205.45 ± 65.64	13.94 ± 0.55	68.96 ± 4	222	3.46	1.56
Track 3	ASCENT 1	120.01 ± 46.66	252.52 ± 81.22	11.67 ± 1.66	62.29 ± 8	98	2.42	2.47
Track 4	ASCENT 1	97.55 ± 24.54	167.54 ± 32.55	13.74 ± 0.89	61.39 ± 10	92	1.42	1.54
	ASCENT 2	93.10 ± 33.08	187.27 ± 41.12	10.33 ± 2.52	60.35 ± 5	120	3.60	3.00

Track 2: the pavement is in gravel, the start is located at 100 masl, its length is 1.79 km, with an elevation gain of 5.6 m. The subjects, on average, performed on the track at

14.5 ± 3.6 km/h with a mean HR of 148 ± 21 bpm and 78 ± 8 %HR_{max}, and a mean VO_2 of 21 ± 5 mL/kg/min, while the mean MET was 5.9 ± 1.3 and the mean power was 71.73 ± 27.79 W. The track is characterized by one ascent, reported in Figure 5, with a slope of 1.56% and a peak power of 205.45 ± 65.64 W, the details of which are listed in Table 1.

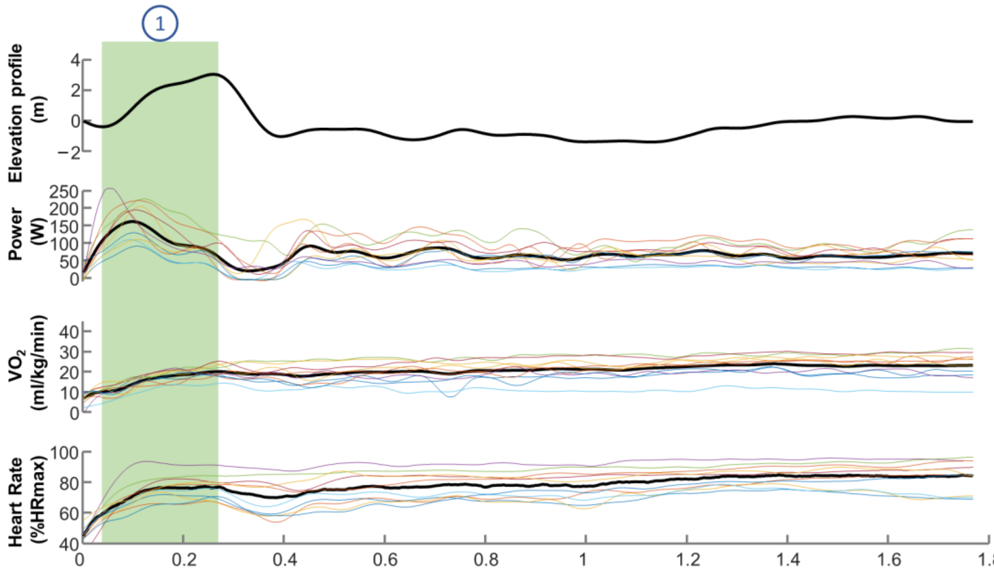

Figure 5. The elevation profile of T2 is shown in the upper panel. The number 1 indicates the ascent section along the path. Mean signals of power, VO_2/kg, and HR for the participants are reported in black while each color refers to a single subject.

Track 3: the pavement is in gravel, the start is located at 161 masl, and its length is 0.96 km, with an elevation gain of 3 m. The subjects, on average, performed on the track at 15.5 ± 3.8 km/h with a mean HR of 134 ± 24 bpm and 72 ± 12 %HR_{max}, and a mean VO_2 of 22 ± 5 mL/kg/min, while the mean MET was 6.2 ± 1.5 and the mean output power was 71.23 ± 37.51 W. The track is characterized by one ascent, reported in Figure 6, with a slope of 2.47 and a peak power of 252.53 ± 81.22 W, the details of which are listed in Table 1.

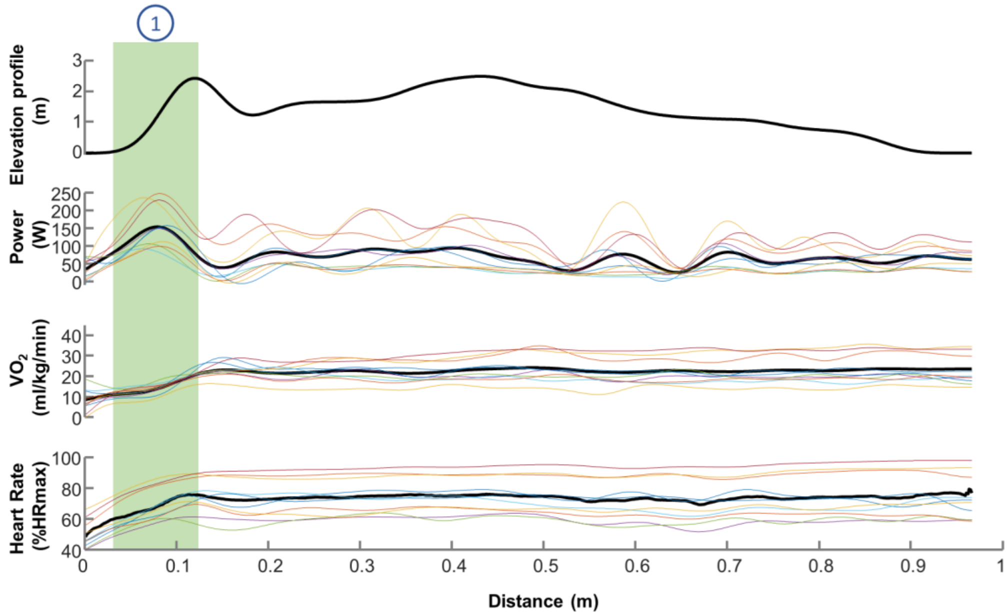

Figure 6. The elevation profile of T3 is shown in the upper panel. The number 1 indicates the ascent along the path. Mean signals of power, VO_2/kg, and HR for the participants are reported in black while each color refers to a single subject.

Track 4: the pavement is in gravel, the start is located at 162 masl, and its length is 2.66 km, with an elevation gain of 23 m. The subjects, on average, performed on the track at 12.2 ± 1.9 km/h with a mean HR of 146 ± 20 bpm and 78 ± 6 $\%HR_{max}$, and a mean VO_2 of 25 ± 3 mL/kg/min, while the mean MET was 7.3 ± 1 and the mean output power was 76.02 ± 14.31 W. The track is characterized by two ascents, reported in Figure 7, the details of which are listed in Table 1. Ascent 2 has the higher slope, at 3%, and a peak power of 187.27 ± 41.12 W. During the execution of this track, one subject independently decided to interrupt the test; for this reason, the results presented refer only to nine subjects.

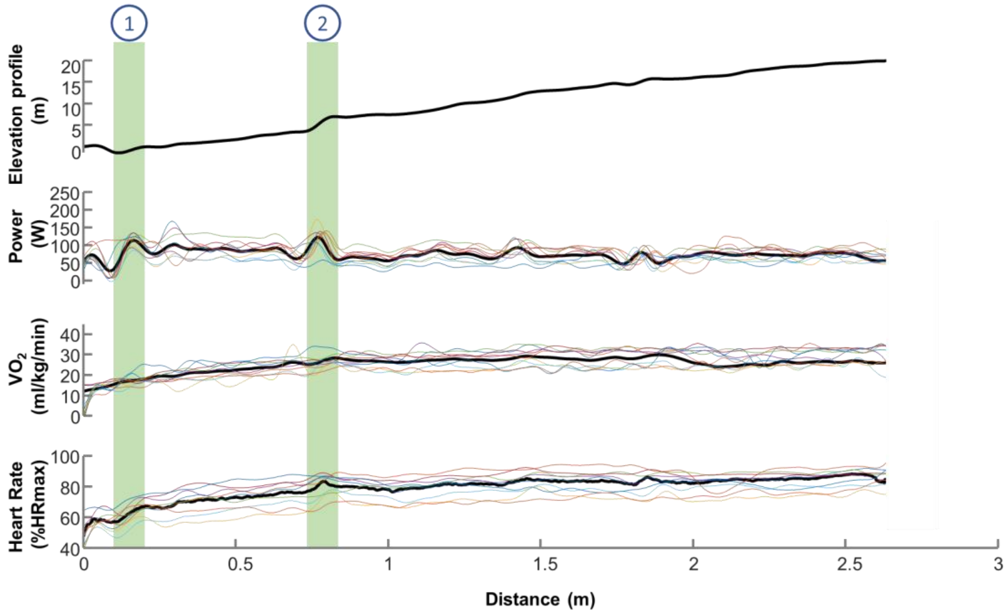

Figure 7. The elevation profile of T4 is shown in the upper panel. The numbers indicate the 2 ascents along the path. Mean signals of power, VO_2/kg, and HR for the participants are reported in black while each color refers to a single subject.

3.2. PA Feasible on the Tracks

As expected, in all the four tracks the mean power is linearly correlated with the mean speed (T1: r = 0.96, $p < 0.001$; T2: r = 0.95, $p < 0.001$; T3: r = 0.95, $p < 0.001$; T4: r = 0.97, $p < 0.001$). All four tracks provided opportunities for engaging in activities that can be considered at least moderate (≥3 MET). All the participants who completed T4 attained, throughout the whole track, vigorous PA (≥6 MET). The Pearson correlation was carried out to verify the possible relationship between average track speed (independent variable) and MET (dependent variable). The two variables resulted correlated are as follows. T1: r = 0.90, $p < 0.001$; T2: r = 0.89, $p < 0.001$; T3: r = 0.83, $p = 0.003$. On these bases it was possible to identify the threshold speed at which vigorous intensity PA was attained: 14.2 km/h, 14.8 km/h, and 14.8 km/h for T1, T2, and T3, respectively.

4. Discussion

The present study aimed to identify and describe some tracks, to evaluate their physiological demand and finally, to offer valuable insights for designing appropriate exercise intensities tailored to these tracks. The main findings are as follows: (1) the urban area of Brescia presents tracks suitable for HB usage, each demanding moderate to vigorous levels of ergometabolic effort; (2) speed modulation can ensure the possibility of changing the level of required effort; (3) planning to cycle on these tracks, even at a self-selected velocity, could be an extremely efficient way to meet the WHO PA recommendations.

4.1. Track Characteristics

The identified tracks are well integrated within the urban area. They are conveniently located near the city center and can be easily accessed from multiple neighboring districts.

All tracks feature dedicated parking lots for individuals with disabilities or limited mobility. Given the lack of ease in transporting HBs on public transportation in Italy, the proximity of bus stops is not relevant to the objectives of this study. As the tracks are dedicated to walkers or cyclist, with no intersections by car streets, they provide a safe and accessible environment for practicing PA, particularly for users with HBs. Most of the terrains are suitable for hand-cycling, although some users reported slight discomfort when riding on gravel.

The elevation gain of three out of four tracks is moderate (less than 10 m), making them suitable for individuals with a wide range of aerobic fitness levels. However, track 4 presents a more challenging elevation profile, with an elevation delta of 23 m that requires greater cardiorespiratory involvement (mean HR 78 $\pm$ 6 $\%HR_{max}$ and a mean MET of 7.3 $\pm$ 1).

To further understand the unique characteristics of each track, we analyzed the ascents and described their features in Table 1. Notably, none of the tracks feature ascent slopes greater than 5%, with the steepest segment being "ascent 2" in track 4 with a slope of 3.0%. Importantly, this is well below the threshold of the wheelchair ramp slope required by the Italian government (10%), as specified in Decreto Ministeriale 236/1989. This suggests that individuals with various levels of physical fitness can effectively use the tracks without experiencing any structural barriers that could preclude or limit exercise from them [15,32]. Additionally, the length of the ascent sections varied within and across tracks, for example, track 1 presents the longest (341 m) and the shortest (88 m) ascents. However, the characteristics of the trails, especially the features of the ascents, do not prevent their use by HB users. Allowing freedom in selecting the pedaling pace, individuals who tackled these segments with lower power levels showed non-prohibitive cardiorespiratory values. This information can help users tailor their exercise routine based on their fitness level and goals.

4.2. Required Mechanical Power and Ergometabolic Demand

The results of the HR and MET measurements provide valuable information about the intensity of PA performed during each track [33]. Regarding HR, the mean values obtained during the four tracks were in the moderate-to-vigorous intensity range (i.e., 64-95% of the maximum HR) according to the American College of Sports Medicine guidelines [8]. Based on HR individual kinetics shown, in Figures 3–7, T4 elicited more consistent and concentrated ergometabolic responses above vigorous intensity. In contrast, T1, T2, and T3 exhibited a broader range of ergometabolic responses, ranging from moderate to vigorous PA. Regarding MET, the mean values across the four tracks also positioned them within the moderate-to-vigorous intensity spectrum, consistent with established guidelines [7,8]. Specifically, in both T1 and T3, the mean METs were similar at 6.6 $\pm$ 1.5 and 6.3 $\pm$ 1.5, respectively, reflecting an intensity fluctuating around the vigorous level. In T2, the mean MET was slightly lower at 5.9 $\pm$ 1.3, possibly due to the comparatively lower intensity of the track. Notably, T4 exhibited the highest mean MET at 7.2 $\pm$ 1, signifying a distinct vigorous intensity level. This aligns with the extended track duration and higher elevation gain in T4.

The concordant HR and MET outcomes underscore the distinct intensity levels among the four tracks, with T4 representing the most intense, T3 being less intense, and T1 and T2 falling within the middle range of intensity. Nonetheless, as the subjects conducted self-paced biking, we were able to observe that even at lower speeds, at least three METs were achieved, indicating that the activity could be considered moderate-intensity, as recommended by the ACSM and WHO [7–9], it is worth noting that achieving vigorous activity levels can be readily attained by hand-cycling at speeds exceeding 14.2, 14.8, and 14.8 km/h in T1, T2, and T3, respectively. In contrast, T4 facilitates vigorous PA regardless of the cycling speed chosen by the participants.

The HR findings align with the calculated MET values across all four tracks, and this alignment holds significance as individuals can readily obtain their HR data using smartwatches or HR monitors. Additionally, it enables individuals to adjust their pace based on the MET level corresponding to the desired intensity of the PA they intend to engage in.

The characteristics of the tracks, such as length, elevation gain, and number and steepness of ascents, are consistent with the observed HR and MET values. To delve into specifics, T1 stands out with the highest number of ascents and a notable elevation gain, contributing to relatively elevated mean HR and MET values. Similarly, T2 has comparable MET values with those of T1, yet it showcases a milder elevation gain and fewer ascent sections. In contrast, T3 records the lowest elevation gain and the fewest ascent segments, thus yielding lower HR and VO_2 values. Finally, T4, despite featuring a lower count of ascent sections, exhibited the highest, uniformly distributed elevation gain of 23 m. T4 resulted in being the most challenging track. These findings highlight the varying intensity levels present among the four tracks, providing valuable guidance for individuals aiming to align their track selection with their fitness capacities and specific PA targets. Such insights empower individuals to make informed decisions regarding track choices that resonate with their fitness levels and exercise aspirations. For instance, individuals in pursuit of a more rigorous workout might gravitate toward T1 or T4, whereas those desiring a milder workout might opt for T3. T2, with its moderate attributes, could be a suitable selection for individuals seeking a balanced workout experience.

The results indicate that HB riding is a physically demanding activity that can provide moderate to high levels of PA. The VO_2 values recorded at the wattage levels employed for the execution of these exercises, compared to those obtained using the same wattages in leg pedaling activities, suggest higher ergometabolic effort being required during arm pedaling. This result highlights lower performance in the execution of tasks involving the upper limbs compared to that in activities performed with the legs [34–36]. The linear relationship between MET and speed found in three out of four tracks suggests that the increase in cycling speed was accompanied by a relative gain in power, which is in line with previous studies [37,38]. However, in T4, which had the largest elevation gain, participants performed only vigorous PA, highlighting the impact of topographical characteristics on the relationship between MET and speed. Indeed, on average, the self-selected speed in T4 ranged from 9 to 15 km/h, and metabolic engagement ranged from 6 to 8 MET. This narrow range of cycling intensity is likely due to the topography of the track, which had a significant impact on the performance of the HB riders.

All tracks showed a linear relationship between power and speed, which is expected given the main resistances to cycling with a HB. It is important to note that the tensorized HB used in this study was designed for leisure time, and the influence of air drag on these correlations would be more significant in competitive settings [39–41]. Furthermore, the surface condition of the tracks may have affected the resistance participants had to overcome. Thus, the topographical characteristics of the track and HB design should be considered when interpreting the relationship between physiological parameters and HB riding, especially in competitive settings.

4.3. Urban Infrastructures and Leisure Time PA

People with disabilities, particularly those with spinal cord injuries (SCIs) or lower limb amputations, reduce their daily PA due to their physical limitations. In Italy, approximately 80% of people with disabilities are reported to be entirely inactive in terms of participating in sports and PA [42]. Therefore, most of them do not reach the required health-related PA thresholds [43–46], which, in terms of amount and intensity according to Bull and colleagues [7], correspond to the same target as able-bodied individuals. Recent research on inclusive policies and accessible infrastructure has highlighted the importance of promoting PA among people with disabilities [46]. Regular PA in the SCI population improves physical and psychological health through decreasing anxiety, depression, and pain [47], increasing functional autonomy and, as a consequence, improving life's quality [48–50]. For individuals with SCI, incorporating PA into daily life is challenging due to the restricted mobility of wheelchairs. For example, most Italian cities sidewalks that are partly unsuitable due to being too small or having an uneven surface.

In terms of infrastructure for people with disabilities, Brescia has made significant progress in recent years, with several public buildings and transportation options becoming more accessible. The rising interest in cycling and hand-cycling in Brescia is complemented by the city authorities' active endorsement of this mode of transportation, coupled with ongoing efforts in constructing new bicycle routes also suitable for HB, all signaling a dedicated pursuit of this goal. Recognizing the need for enhanced safety measures for cyclists, HB users, and pedestrians alike, the imperative of establishing a comprehensive network of HB and bicycle routes within the city becomes increasingly apparent. The implementation and the usage of these dedicated routes significantly decrease the emission impact, increasing the contribution to sustainability with a particular focus on people with limited motor control [51]. Swift implementation of this complete network not only proves financially viable but also promises a profitable venture with the anticipated surge in hand-cycling participation [52]. Engaging in HB practice on the described tracks could notably enhance physical fitness levels, consequently fostering increased altruistic PA along the dedicated cycling and hand-cycling routes across the city. This could be an added value of this study.

Indeed, it is clear to the authors that four tracks useful for hand-biking do not fill the needs for PA and sport for citizens with SCI. To improve PA and sport in people with disabilities [42], we should focus, at least, on two dimensions of living: the effectiveness of education and the availability of quality, suitable spaces. Looking at the second, we might remember that Italy has one of the most advanced legislations in the world, and it would be almost enough to make the concepts and the norms real. We are aware that this could look like a simplistic way of treating the theme, but the application of the law and the sensitization and education of people to respect them (we mean in the building process and, once built, in respecting the spaces of the bodies—each body—in the cities) [32] is the basis of every improvement. Looking at the first, to instill in persons—each person—the motivation to be active, we should start from scratch, so therefore we should start from school [32,53].

The results of this study offer a valuable resource for designing informative graphics, effectively showcasing the range of potential forms of PA achievable on these urban tracks. This study underscores the importance of governments prioritizing the characterization and development of dedicated handcycling tracks. Such initiatives hold the potential to significantly enhance PA opportunities for individuals with SCI, fostering a culture of active and healthy living within the SCI population. To further encourage adherence to these tracks, the municipality should implement initiatives to enhance usability. Providing resting areas along the paths, equipped with water fountains, would help HB users engage in PA more comfortably. Given the size of HBs, the periodic inclusion of spaces wide enough to allow a U-turn is also crucial. This would give riders flexibility to reverse directions as needed.

4.4. Structured PA

Daily life activities are essential for achieving an active lifestyle, as highlighted by the WHO's motto "Every move counts towards better health" [7]. Engaging in PA can increase non-exercise activity thermogenesis, which is a significant factor in increasing total daily energy expenditure. Studies have shown that low non-exercise activity thermogenesis is associated with obesity [54]. However, for people who use wheelchairs, engaging in daily life activities may be difficult or impossible, making structured PA crucial to meeting the WHO's PA recommendations.

The tracks presented in this study were studied to promote PA in leisure time and structured settings. Located in parks close to the city of Brescia, these tracks' design is appropriate for encouraging frequent and enjoyable participation in PA. The surrounding green environment enhances the PA experience, making it more enjoyable than indoor activities. Additionally, the tracks are easily accessible to people of all abilities, with no barriers, obstacles, or steep slopes, making them a suitable option for individuals with disabilities. Cycling on these paths provides an opportunity to perform PA at an intensity that meets institutional recommendations for health benefits, such as those from the ACSM [8] and the WHO [7,9].

While spontaneous PA is important [55–57], planning and structuring PA can provide additional health benefits [58,59]. Studies have shown that these tracks are suitable for a variety of aerobic exercises, such as steady-state aerobic training or high-intensity interval training. Both training methods are effective in improving cardiovascular and metabolic health and VO_2max, and are well tolerated by most individuals [10,11]. Therefore, using these tracks can represent a convenient and effective way to achieve PA and promote overall health and well-being.

4.5. Limitations

One limitation of this study is that the experimental protocol was designed and tested on able-bodied participants only. While the findings provide valuable insights into the physiological responses of able-bodied individuals, it is important to acknowledge that individuals with SCI may have different physical capabilities and limitations. Therefore, the observed physiological responses may not necessarily be generalizable to individuals with SCI. To obtain a more accurate understanding of the effectiveness of the proposed experimental protocol in promoting PA in this specific population, future research should consider including individuals with SCI as participants. By incorporating participants with SCI, researchers can gather more reliable and comprehensive data that can inform the development of tailored PA interventions for this population. This would contribute to a more inclusive and representative understanding of the potential benefits of the experimental protocol for individuals with SCI.

Furthermore, future research could explore the relative effort of subjects based on their varying physical fitness levels and speeds, allowing for a more comprehensive comparison. This could lead to a more in-depth statistical analysis based on the subjects' performance. Additionally, expanding the number of tested tracks could be instrumental in thoroughly describing the correlation between a track's general characteristics and its ergometabolic engagement.

5. Conclusions

In summary, this study accomplishes three key objectives: (1) comprehensive descriptions of the tracks' topographical features and ascents deemed suitable for all HB users; (2) a detailed analysis of ergometabolic and power engagement indicating that each track enables PA at a moderate intensity and specifies the velocity required for vigorous PA; (3) robust data for individuals to assess whether a track aligns with their capabilities or what specific activities can be undertaken on it. This study introduces a valuable addition to the array of muscle-engaging, low-impact urban transportation options, providing a practical tool for individuals interested in inclusive and sustainable PA practices.

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