Original Article

The mHealth in the canine assisted therapy: the design and application of a kit for the wearable monitoring during a walking session

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Contributions: (I) Conception and design: D Giansanti; (II) Administrative support: D Giansanti; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: D Giansanti; (V) Data analysis and interpretation: D Giansanti; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Background: We are today assisting to an increasing interest to the animal assisted therapy (AAT). Among the goals of the AAT there is to improve a patient's psychological and physiological condition during the rehabilitation therapies. Several studies showed the health benefits (psychological and physiological) for the human subject thanks to the AAT. Today, according to the new central position of the pet, the approach must be revised in a more general and bidirectional approach embedding the assessment of the health benefits contemporary for the two actors, human and pet.

Methods: Among the most commonly used types of AAT there is the canine assisted therapy (CAT). The study focused to the CAT and was dedicated to the design and validation of a wearable system for the assessment of physiological parameters during the walking of the two actors man and dog. A properly designed case-study involved a human (age 40; height 1.80 m; weight 80 kg) with three dogs with different sizes. It has been performed in a rectilinear walkway of 1 km of asphalt with 15 repetition with each one of the three different dogs at a speed typical for a walk.

Results: The study showed a mean error ≤0.6% in the step counting. The study also showed: the feasibility to use parameters correlating the human and dog motion activity; a high acceptance of the methodology as assessed by 5 independent observers and an interesting perspectives for the future scenario of investigation of the medical scientific evidence of the approach based on the CAT.

Conclusions: From a general point of view the work highlights the importance and the utility of the design and application of tool for the contemporary monitoring of the man and the dog during walking and other activities.

Keywords: Mobile health; animal assisted therapy (AAT); canine assisted therapy (CAT)

Received: 02 September 2019; Accepted: 20 November 2019; Published: 05 April 2020.

doi: 10.21037/mhealth.2019.12.08

View this article at: http://dx.doi.org/10.21037/mhealth.2019.12.08

Introduction

We are today assisting to: An increasing interest to both the animal assisted therapy (AAT) and to the pet quality of life and health. The animal-assisted therapy is an alternative or complementary type of therapy that involves animals as a form of treatment. Among the goals of AAT there is to improve a patient's psychological and physiological condition during the rehabilitation therapies (1-7). The increasing interest into the pet quality of life and health is a direct consequence of the recognition to its contribute to the society. Several studies showed the health benefits (psychological and physiological) for the human subject thanks to the AAT. Today, according to the new central position of the pet, the approach must be revised in a more general and bidirectional approach embedding the assessment of the health benefits contemporary for the two actors, human and pet (8). Among the most commonly used types of AAT there is the canine assisted therapy (CAT). Among the most used CAT applications in psychological and physiological rehabilitation there are: the (a) *co-presence* during the dynamic activity (in particular the walking) and the (b) *co-presence* in the Area of living (mainly the home). It was introduced in (8) a conceptual model for the contemporary parameters monitoring of the two actors during the two applications (a,b) and able to provide a quantification of the utility of the CAT. The model was based on to two *sub-systems*. The first *sub-system* is a wearable mobile solution with kinematic sensors (9,10) for the human and the dog monitoring in (a) during walking also integrable with further technology (11-13) for the walking test monitoring. The second *sub-system*, allowing the monitoring in (b), is based on RFID technology. The first *sub-system* was completely terminated and implemented and we are currently implementing the second domotic *sub-system*.

Purpose

A common scenario of the CAT use is the walking with a dog. This plays an important role both in physiological and psychological health. However, up to now, none has investigated in details this mechanism by means of a detailed quantitative analysis focused on the parameters connected to the walking activity (such as the frequency and duration of walking, the intensity of exercise, the number of steps). Furthermore, up to now, none has attempted to perform an investigation that at the same time faces the monitoring and analyzing of the parameters in the both actors (humans and dog): there is no doubt that a such monitoring could be of aid in this field of the CAT.

The principal objective of this study is the scientific dissemination of the design, test and application of the sub-system dedicated to the walking monitoring based on a wearable kit able to monitor at the same time the walking activity of the two subjects (human and dog). The further principal objectives are the following:

- ❖ The design of a tool capable to generate medical knowledge around the CAT during walking;
- ❖ Investigate the scientific relevance of the use of the CAT during walking;
- ❖ The generation of new models of care based on the CAT during "walking sessions";
- ❖ To provide biomedical data of humans and dog related together.

The secondary ambitious objective is the launch of a methodology able to connect the *mHealth-for-the-man* and the *mHealth-for-the-dogs*.

Methods

The design of the system based on a wearable kit

Figure 1 shows the two components of the kit for the monitoring of the dynamic activity, also briefly introduced in (8) where it is also fully described a validation in a case study. The first component has been designed for monitoring the "steps" in the human; the second component has been designed for monitoring the "steps" in the dog. The first component, the *wearable device* for the human (*WD x H*) (*Figure 1C,D*) is the same used in (14), i.e., a *Gastrocnemius Expansion measurement Unit* (*GEMU*). The core element of the GEMU is a Force Sensing Resistor (FSR) affixed at the calf level for the step monitoring. The second component, dedicated to the dog, is the Wearable Device for the Pet Animal (*WDxPA*). *Figure 1A* shows the affixation of the *WDxPA* on the dog-harness at the level of the scapula. *Figure 1B* shows a detail about the lock solution used in the device. *Figure 1D* shows the recharging unit, identical for the two components. The RX-TX unit used in the two transmission lines is the AUREL XTR-434H (Aurel, Italy) unit. At the Level of the Receiving Unit there is also an A/D converter NI USB 6008 (National Instruments, USA) which, combines the two Radio-Links and converts them into digital for the Personal Computer. *Figure 2* shows the architecture of the kit. The WDxPA is based on two sensors:

- ❖ an accelerometer sensor (3031-Euro Sensors, USA) to the detect the acceleration during walking. After some trials we have detected that at the level of the scapula of the dog (PA) the vertical acceleration pecks are more evident and correlated to the impacts on the ground;
- ❖ a rate-gyroscope (Gyrostar ENC-03J-Murata, Japan) to assess the rotational rate during walking, useful to create medical-knowledge and for correcting the step counting when the contributes of the *dog-trot**

* It has been decided, at this stage of research, to not separate the "spikes" of the dog-trot or of the dog-gallop from the dog-step.

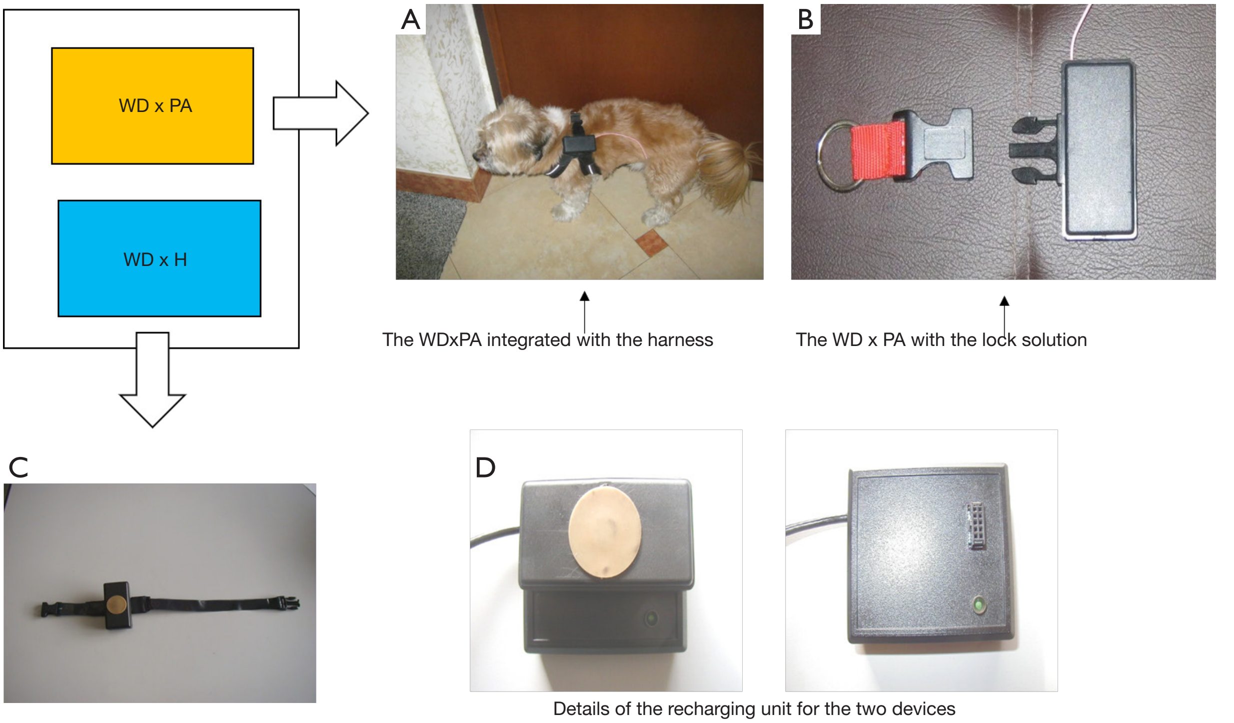

Figure 1 The components of the *wearable sensor* unit (Kit).

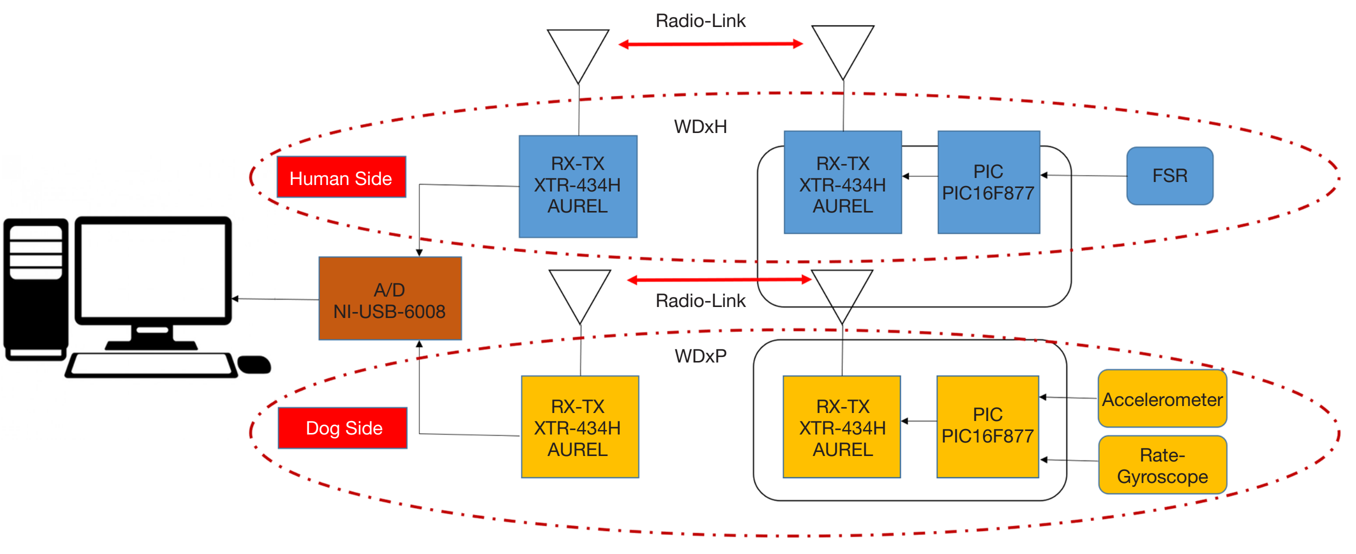

Figure 2 The architecture of the *telemetric system*.

and *dog-gallop** are increasing with the speed.

However:

(I) these spikes are present only when the walk (true objective of the study) changes into running;

(II) the functions of the system also allow these detections in terms of number and percentage.

The application in a case-study

The kit has been tested in a case-study. The test has been

Table 1 Outcome of the investigation

ID	Subject (man/dog)	Speed	Steps	Mean error	Dev-SD
1 H	Human	4.9 Km/h	1,270.5	0.4%	0.1%
1 D	Small-size-dog	4.9 Km/h	6,294.3	0.6%	0.4%
2 H	Human	5.0 Km/h	1,260.2	0.4%	0.1%
2 D	Medium-size-dog	5.0 Km/h	4,301.0	0.5%	0.3%
3 H	Human	5.1 Km/h	1,254.1	0.4%	0.1%
3 D	Big-size-dog	5.1 Km/h	3,100.2	0.4%	0.2%

Table 2 The index COR and the error before the correction with the rate-gyroscopes (R-Gyr)

Configuration	COR	Mean error without the correction by the R-Gyr
1 H -1 D	4.95	0.9%
2 H -2 D	3.41	0.7%
3 H - 3 D	2.47	0.4%

Table 3 The acceptance of the methodology

Parameter	Evaluation (min 0; max 3)
User-friendly	2.9
Failure-rate	2.6
Technical sound	2.6
Usefulness	2.9

Table 4 Costs of the prototype with simulated cost for 10 pieces

Description	cost
Costs of materials (prototype)	2,300 Euro
Cost of the study	4,900 Euro
Cost of construction	200 Euro
Cost for 10 pieces	20,000 Euro

performed in a specific route. The instruction was to walk with a speed not causing physical fatigue.

First configuration (1 H - 1 D)

- ❖ A human (1 H) (age 40; height 1.80 m; weight 80 kgW);
- ❖ A small size dog (1 D), Jack Russell Terrier (age 7; male; height 37.5; weight 8.1 KgW).

Second configuration

- ❖ A human (2 H) (age 40; height 1.80 m; weight 80 kgW);
- ❖ A medium size dog (2 D), Border Collie (age 6; male; height 52.5 cm; weight 19.5 KgW).

Third configuration

- ❖ A human (3 H) (age 40; height 1.80 m; weight 80 kgW);
- ❖ A large size dog (3 D), Golden Retriever (age 4; male; height 58.5 cm; weight 33 KgW).

The route was 1 km long, rectilinear, with asphalt and no obstacles. Each trial was repeated 15 times. The human was at the first level of the Tinetti Test. All the dogs were healthy. *Table 1* shows the outcome after three sessions associated to the 3 trials monitored also by means of a commercial GPS.

Table 2 reports a coefficient of relationships (COR) between the Number of steps assessed by means of the *WD x H* and the *WD x PA* defined as follows:

$$COR = \frac{Nstep(Dog)}{Nstep(Human)} \quad [1]$$

Where: *Nstep(dog)* is the mean number of steps of the dog; *Nstep(H)* is the mean number of steps of the human. This index becomes useful to estimate the Number of steps of the Human after measuring the Number of steps of the dog with the proper device and vice versa.

Table 2 shows the mean error also in the case of the WDxPA without the correction based on the rate-gyroscopes; this error increases due to the contribution of the dog-trotting and/or dog-galloping and with the decreasing of the size of the dog. However, this error was always ≤0.9%.

The methodology has been assessed also in acceptance. Five independent observers assessed the methodology according to four parameters (user-friendly; failure-rate; technical soundness, usefulness). The *Table 3* details the high value of acceptance of the methodology. In particular the evaluation indicated an acceptance always ≥2.6 (min =1; max =3) for all the issues.

Table 4 details the costs of the prototype (first 3 elements). The total cost for the development of the prototype was 7,400 euro. The impact of the cost of the study was the higher contribution; it also included the simulation of the outcome and the costs of the Placement & Routing. All the costs comprise the materials, the administrative-indirect-costs and the working-hours of the workers in the project. For a large production these costs are expected to decrease. The simulated cost for the production of 10 pieces is 20,000 euros (2,000 euro per piece).

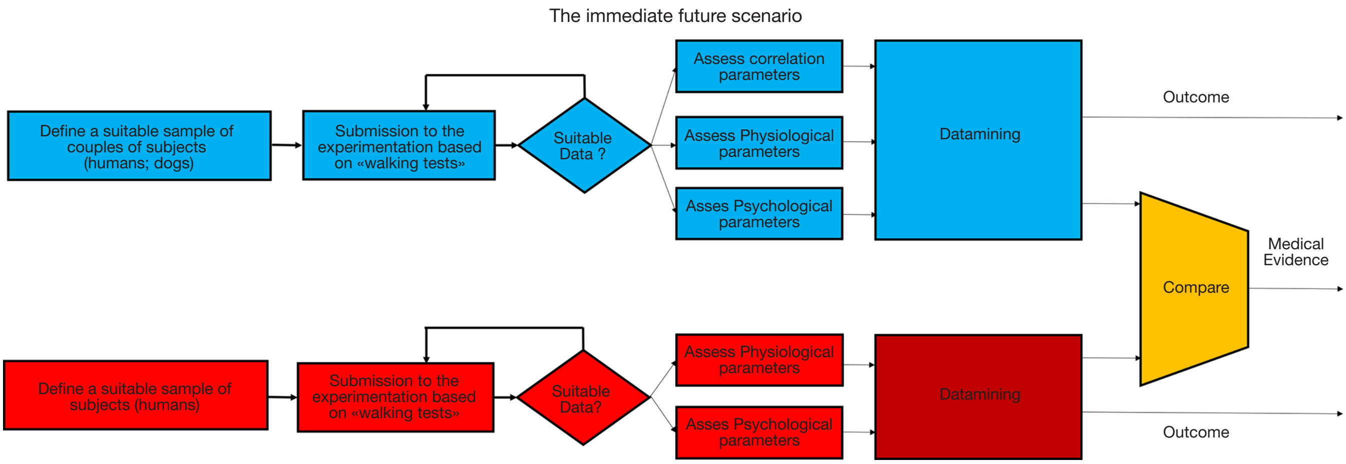

Figure 3 The future scenario of the study.

The design of a wide ranging protocol

As a part embedded of this study, we have planned the scenario of the development (*Figure 3*). *Figure 3* shows the immediate future scenario of the study. Two groups of subjects will be involved. The first group will comprise couples of Men and dogs. The second group will comprise only Men. The experimentation based on "walking tests" will allow the collection of data not only to obtain (after assessment and data minging) psychological/physiological and/correlation parameters but also "medical evidence" of the improvement of these parameters with the aid of pet animal (A versus B).

The assessment of the physiological parameters in (A) will be extended also to the dogs. The "walking tests" will be designed according to the standard. The 1-mile and 6-minute tests will thus be used in the protocol (11-13).

The following subjects having demonstrated to positively respond to the CAT will be considered in the study:

- ❖ older individuals;
- ❖ subjects under mental rehabilitation (as for example with depression and anxiety);
- ❖ subjects with risk of heart failure;
- ❖ subjects with hypertension with and without other factors of risk as for example cholesterol and triglycerides).

Discussion and conclusions

Highlights in the study

Many studies utilizing dogs have tried to ascertain the health benefits of dog ownership or CAT (1). Some investigations outlined improvements in behavior in demented persons, in subjects with anxiety, depression, and other mental pathologies (1). Several investigations focused on the effect of dogs on physical health suggest (1-8) that:

- ❖ dogs can lower blood pressure, help subjects with risk of heart failure and with vascular risk factors as for example cholesterol and triglycerides;
- ❖ dogs play an important role in motivating men during the "walking sessions" and in the improving the performances of the task and, as a direct consequence, in the improving the physical health and the mental health.

Regarding the mechanism one might speculate that, rationally, the need to walk a dog might create a need to walk more, and that increased physical activity might be more associated with the pet's needs than those of their owners.

The attention to health of the dog (8) furthermore also increases the importance to conduct the dog to a constant physical exercises for example the walking. Indeed, the walking also for the dogs is useful to prevent obesity, diabetes, heart problems etc. This reciprocally create a health benefit also for the human who conduces the dog: the dog and the human become reciprocal therapists!

The study here reported focused on the walking monitoring of the two actors in the CAT.

As it is well known the step of the dog is one of the most complex and fascinating wonders of mother nature and thus the accelerometry and the angular-rate-metry (15-18) strongly used in Motion Analysis, could be useful, starting from the “step counting”, to investigate this as for the man.

From a global point of view, the work proposes an innovative kit for the activity monitoring during the “walking sessions” of a human with a dog. The kit was tested with three different dog sizes and pointed out performances interesting performances. From a global point of view the study shows a new direction of research that could contribute to create a scientific field between the Fitness and the Sports Medicine, not separated for human and dog, but joined by means of the clue of the Integrative Medicine (19,20).

The future work will comprehend the deepening of the investigation on a wide sample of couples of humans and dogs using a specific protocol based on both the kinematic monitoring and the periodical monitoring of the physiological and psychological parameters in order to assess the improvement of health conditions of the two actors. The wearable monitoring starting from the step counting will be gradually enriched also with other useful functions.

Added values in the study

The first added value is represented by the wearable kit capable (A) to monitor the human and the dog walking activity (B) to provide medical knowledge for the two actors (C) to provide the scientific evidence of the utility of the CAT during walking (D) to connect two different sides of mHealth for humans and for dogs.

The second added value is represented by (E) the test and the outcome that showed the feasibility to use the methodology in an immediate scenario of investigation (F) also in terms of costs of construction.

The third added value is the (G) proposal of new parameters to be used to assess the exercise of the two actors.

Acknowledgments

Funding: None.

Footnote

Conflicts of Interest: DG serves as an unpaid editorial board member of mHealth from May 2019 to Apr. 2021. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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doi: 10.21037/mhealth.2019.12.08
Cite this article as: Giansanti D, Maccioni G. The mHealth in the canine assisted therapy: the design and application of a kit for the wearable monitoring during a walking session. mHealth 2020;6:16.