Universidade de Aveiro Secção Autónoma de Ciências da Saúde
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Smartbike: Future prospects of a bicycle for the elderly

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Smartbike: Visão prospectiva de uma bicicleta para idosos

Smartbike: Future prospects of a bicycle for the elderly

Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Gerontologia realizada sob a orientação científica do Professor Doutor Aníbal Rui de Carvalho Antunes das Neves do Departamento de Didáctica e Tecnologia Educativa da Universidade de Aveiro.

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palavras-chave

Gerontotecnologia, Bicicleta, Idosos, Design For All, Gerontologia.

resumo

Andar de bicicleta pode ser uma forma de melhorarmos a saúde enquanto nos divertimos e protegemos o meio-ambiente. Tendo em conta isto, seria de esperar que bicicletas adequadas se encontrassem disponíveis a toda a população. No entanto, as convencionais bicicletas disponíveis no mercado não tomam em consideração as pessoas idosas e as limitações que acompanham o processo normal de envelhecimento.

Este projecto tomou como ponto de partida um estudo anteriormente elaborado pelo próprio autor do presente estudo e deu a este uma continuação. Neste estudo anteriormente realizado (Smartbike: A vehicle for the elderly, 2007) o autor desenvolveu um modelo de uma bicicleta destinada à população sénior (Smartbike), tomando em consideração as suas limitações e questões de segurança. O presente estudo tem como objectivo principal validar a pertinência da construção de bicicletas para seniores. Com esta finalidade, alguns objectivos específicos foram estipulados: conhecer e caracterizar os modelos de bicicletas para seniores disponíveis no mercado; obter informação concreta sobre os potenciais utilizadores de bicicletas para seniores e possivelmente da Smartbike; tomar conhecimento acerca dos programas existentes de promoção da saúde dos idosos que utilizem a bicicleta como um instrumento; e fazer o planeamento do teste do futuro protótipo da Smartbike.

Algumas das descobertas mais relevantes resultantes deste estudo incluem uma revisão geral das bicicletas para seniores disponíveis no mercado, com os seus pontos fortes e pontos fracos; uma examinação aos potenciais utilizadores de bicicletas para seniores e da Smartbike em particular, descobrindo as suas experiências pessoais, preferências e atitudes ao utilizar a bicicleta, ou para com as bicicletas; e um plano para o teste do futuro protótipo da Smartbike.

Keywords Gerontechnology, Bicycle, Elderly, Design For All, Gerontology.

Abstract

Cycling can be a pleasant way of improving one's health while enjoying and protecting the environment at the same time. With this in mind, it would be expected that everyone should have access to a suitable bicycle. However, the conventional bicycles available in the market today do not take in consideration the elderly person and their limitations that come along with the ageing process.

This project took a study previously developed by the author of the present study for a starting point and gave it a continuation. In this study (Smartbike: A vehicle for the elderly, 2007) the author developed a model of a bicycle aimed at the elderly person (Smartbike), taking in consideration their limitations and safety issues. The present study has the aim of validating the pertinence of building bicycles specifically designed for the senior population. For this purpose some specific objectives were stipulated: characterizing and getting acquainted with the senior bicycles available in the market; obtaining concrete information about the potential users of senior bicycles in Portugal and possibly future users of the Smartbike; getting acquainted with the existing health promoting programs which use the bicycle as an instrument; and planning the test for the future Smartbike prototype.

Some of the most relevant findings resultant from the study include an overview of the senior bicycles available, with their strong and weak points; a survey on the potential users of senior bicycles and the Smartbike in particular, with their personal experiences, preferences and interests on using a bicycle or towards bicycles; and a plan for the test of the Smartbike future prototype.

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1. Introduction

Population ageing is humanity's greatest achievement, but it is also one of the biggest concerns of our present society today and a worldwide problem. Worldwide, there are at the moment about 650 million people over age 60. By the year 2050, this number will increase to almost 2 billion, which means roughly 20 percent of the world population at that time (WHO, 2007). People are living longer than ever and the fertility rates are lowest ever registered. With this tendency, by 2050 there will be more people aged over 60 than there will be young people aged less than 15, for the first time in history. This dramatic change in the demographic structure will be most accentuated in the more developed countries, where by 2050, the percentage of those aged over 60 will account to about 30 percent. Thus, by 2050, the ratio of working population to those over age 65 will be about 4 to 1; this ratio 50 years ago was 12 to 1. These demographic changes will have huge financial and political consequences (United Nations, 2002).

According to the World Health Organization (WHO), the countries can overcome, or attenuate these consequences, and actually "afford to get old" (WHO, 2002, p.6) if governments, international organizations and civil society establish "active ageing" policies and programs that enhance the health, participation and security of older citizens (WHO, 2002). Active ageing has received a lot of attention in the past few years, especially, side by side with the topic of population ageing concerning most countries' governments. Active ageing is defined by the WHO as "the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age" (WHO, 2002, p.12).

According to the WHO (2002), an active ageing approach to policy and program development has the potential to address all of the challenges of both individual and population ageing. Ultimately, this concept allows elderly people to "optimize their potential for independence, good health and productivity while providing them with adequate protection and care when they require assistance"(WHO, 2002, p.17).

The active ageing concept focus its attention in the idea that maintaining autonomy, and independence, as one grows old is a key goal to ensure quality of life in old age. This can be

obtained in big part by promoting the participation in recreational and physical activity of people as they age. However, not all physical or recreational activity opportunities take the elderly into account. An example of this is cycling, although cycling is an activity that can be both, physical and recreational, as well as social, with innumerous benefits for the older people and everyone in general, its potential for promoting the health of older people has not yet been very explored.

There is no doubt that a bicycle is an excellent tool that can benefit people in a variety of ways. Cycling can be a pleasant way of improving one's health while enjoying the outdoor environment. Cycling is also an excellent form of mobility with numerous advantages over cars especially in the cities. With all this in mind, it would be expected that everyone, despite of their age, should have access to a suitable bicycle. But this is not actually true; in fact, the conventional bicycles available in the market are not exactly designed thinking in all the age groups.

The conventional bicycles available in the market today do not take in consideration the elderly person and their limitations that come along with the ageing process. Although some bicycle producers have started to take into account the elderly person when designing some of their bicycle parts, the number of existing vehicles build focusing entirely the elderly person is yet very reduced. In the recent years, a few progresses have been made in this area, however, not enough to accompany the needs of the present elderly population.

This study took as a starting point a study previously developed by the author himself with the aim of giving it a continuation. The title of this previous study is ***Smartbike: A vehicle for the elderly***, and its goal was to design "a bicycle aimed at the elderly as a specific group, allowing them to keep active and independent in terms of transportation as long as possible, taking in consideration their limitations and safety issues" (Melo, 2007, p3). This study was developed in 2007 at the Arcada University of Applied Sciences in Helsinki, and it was the author's bachelor thesis in Gerontology. The result of this study was a model of a tricycle with an innovative design, which tries to address the specific needs and the limitations of the elderly person that derive from the normal ageing process. Its intention is to offer a safe way for the elderly person to move around and exercise, while at the same time promoting a sustainable environment. Some of the most innovative features of this vehicle model include a frame designed for easy boarding and poor balance, with multiple

adjustment possibilities for comfort, and an handlebar with arm rest and extensible arms for easy control and comfort.

The main aim of the present study was to obtain a strong background support for the Smartbike study before proceeding to the prototyping phase and maybe to a possible future commercialization of the Smartbike. For this some specific objectives were stipulated, they were, obtaining concrete information about the potential future users of the Smartbike, particularly in Portugal; understanding what kind of senior bicycles are available in the market; getting acquainted with the existing health promoting programs which use the bicycle as an instrument; and planning the test of the future Smartbike prototype.

This study is divided in four main parts, Review and Evaluation of the Existing Senior Bicycles in the Market, Survey on the Portuguese Potential Users of Senior Bicycles; Review and Evaluation of Existing Health Promoting Programs Using the Bicycle as an Instrument; and Planning of the Smartbike Future Prototype Test.

In the first stage of this study a literature review was conducted. This literature review promoted a firm background in the specific fields of study and support for the whole development of the study, as also helped to keep updated with the recent studies done in the field. After the main literature review was concluded the development of the four main parts of the study started. After this literature review went on through continued throughout the all study.

The first main part of the study is the Review and Evaluation of the Existing Senior Bicycles in the Market, in this part a review of the senior bicycles market was conducted through the Internet, and eight vehicles were chosen and then reviewed and evaluated. The evaluation of the vehicles was made taking into consideration the aspects pointed out in the literature as the most important ones for a senior bicycle.

The second main part of the study is the Survey on the Portuguese Potential Users of Senior Bicycles, in this part a structured interview was applied to 20 random elderly persons and to 20 elderly cyclists with the purpose of gathering concrete information about them, their personal experiences, preferences and interests on using a bicycle, and or towards bicycles. With further

ideas of possibly trying to find a company to commercialize the Smartbike, this information about the potential buyers of the Smartbike can be of great relevance. Moreover, relevant information for the senior bicycles field can be withdrawn from this survey.

The third main part of the study is the Review and Evaluation of Existing Health Promoting Programs Using the Bicycle as an Instrument, for this part an Internet search was conducted with the aim of finding health-promoting programs that use the bicycle as a tool to activate the elderly people, and then understand how these programs are running, their aim, and outcomes. The information obtained acquainted this study with substantial information about the importance and viability of developing bicycles aimed at the elderly.

The forth and last main part of the study is the Planning of the Smartbike Future Prototype Test. With the Smartbike prototyping phase already taking place, it makes sense to start planning its test. The plan of the test is divided in two parts, a technical part, to take place first, and a usability part involving a study group. The second part is the one requiring more attention during this planning process due to its complexity.

Besides bringing development and promoting very important information for the future of the Smartbike study, this study also generated crucial knowledge and possibly guidelines that can be useful in the future development of bicycles, tricycles, and even of other vehicles for the elderly persons or people with decreased mobility and or balance problems.

1.1. Motivation

The author has had the idea of creating a bicycle aimed at the elderly population for quite a long time. But it was not until 3 years ago that he developed a small study called Smartbike as part of a course in Gerontechnology. After that he started to become even more interested in the subject of bicycles designed for elderly people, so he gave a continuation to his first project and made his bachelor thesis in the same topic, designing a model of a bicycle for the elderly. The project called ***Smartbike: A vehicle for the elderly,*** as it was mentioned in the previous chapter, had the aim of designing “a bicycle aimed at the elderly as a specific group, allowing them to keep active and

independent in terms of transportation as long as possible, taking in consideration their limitations and safety issues" (Melo, 2007). Thus, the present study represents a very important stage in the author's idea of creating a bicycle for the elderly people. The process of validating the pertinence of building bicycles specifically designed for the senior population, along with the preparation of the test of the future Smartbike prototype, is a very important phase in order to be able to give the Smartbike study a continuation. This preparation will offer the needed background before moving on to the prototyping phase and to an eventual future commercialization of the vehicle.

To better understand how this idea came about in first place it is, however, necessary to look at the author's background. The author has had a strong interest in bicycles for very long time. He has been cycling a BMX bicycle for the past 18 years, and competing in the professional level for the past 8 years. Other then bicycles he is interested in the areas of Gerontology, subject in which he has a bachelor degree, and Gerontechnology. The idea for this project has its base in the author's main interests and it can be perceived as an attempt of combining the knowledge from his studies in Gerontology and Gerontechnology, with the experience acquired from his background as a cyclist.

2. Literature Review

The literature review was divided in six chapters. The first chapter covers the subject of active ageing, where an overview of the global ageing phenomenon is made and then the active ageing concept is covered. The second chapter is focused on the subject of balance, where an introduction to how the balancing system function is done, and the effects of the ageing process in this sense are also explained. The third chapter turns its attention to the benefits of maintaining an active lifestyle for the elderly person, regarding not only the importance of physical activity, but also the importance of leisure time. In the forth chapter, an introduction to the benefits of cycling for the society, and for the elderly people in particular, is made based on different studies on the subject. In the fifth chapter the subject of Gerontechnology is covered. In the sixth and last chapter, the subject of quality of life in old age is covered with an emphasis in the importance that mobility has in the lives of the senior citizens.

2.1. Active Ageing

Population ageing is one of the greatest triumphs achieved by the humanity, however, also one of its greatest challenges ever encountered. Global ageing is a phenomenon observed worldwide, declining fertility rates combined with longer life expectancy will ensure the continued “greying” of the world’s population. While in 2006 there were 650 million people aged 60 and over, it is expected that in 2025 there will be a total of 1.2 billion, and in 2050 the “greying” population will reach 2 billion. These numbers can be seen both as a societal achievement but also as a great challenge (WHO, 2007).

Although population ageing has numerous consequences in the society, the typical key issue in the discussion of population ageing is usually its negative impact on the public institutions that must adapt to this demographic change. Within this scope, there are typically two challenges that are given most attention, they are, in first place, the fear that the shift in the number of those economically active (roughly the adult population providing the goods and services in a society) in relation to the number of those economically non-active (the young who are at school, and the old who are retired) will jeopardize the sustainability of the present social systems. In second place, the

challenges for the health care systems. This is mainly due to the fact that as nations age, the prevalence of disability, frailty, and chronic diseases is expected to increase dramatically, and along with this comes increased costs for the system.

According to the World Health Organization (WHO), the countries can afford to get old if governments, international organizations and civil society enact "active ageing" policies and programs that enhance the health, participation and security of older citizens (WHO, 2002). Thus, in order to make ageing a positive experience, longer life must be accompanied by continuing opportunities for health, participation and security. The process for achieving this vision is quoted by the WHO as "active ageing". Active ageing is defined by the WHO as the "the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age" (WHO, 2002, p.12).

This process called active ageing "allows people to realize their potential for physical, social, and mental well being throughout the life course and to participate in society according to their needs, desires and capabilities, while providing them with adequate protection, security and care when they require assistance" (WHO, 2002, p. 12). As the term indicates, active ageing puts emphasis in the word *active*, which refers to the process of continuing participating social, cultural, economic, spiritual and civic affairs, and not only to the ability to be physically active or to take part in the labour force. The word health, within the definition of active ageing, refers to the physical, the mental, and social well-being, thus active ageing gives equal importance to the promotion of physical health, as it gives to the promotion of mental health or social connections (WHO, 2002).

Active ageing has the aim of extending healthy life expectancy and quality of life for everyone as they get old, including those who are frail, disabled and in needed of care. One of its main principles is the acknowledgement of the fact that maintaining autonomy and independence, as one grows older, is a key goal for both individuals and police makers. This acknowledgement involves the understanding of the benefits that maintaining autonomy and independence of the older citizens has, not only for the citizens themselves, but also for the economical and health system.

Good health is an essential factor for older people to remain independent and to be able to play a role in family and community life. The more autonomous and independent senior citizens are, and

the more possibilities they have to keep active, transmitting experience and knowledge, helping their families with caring responsibilities and increasing their participation in the paid labour force, the less economic pressure will be put in the social and health care systems (WHO, 2002).

2.2. Equilibrium and the ageing process

2.2.1. Balance

Balance is a quite complex term to define. The complexity behind defining this term it is due to the fact that it can be interpreted in quite many ways. Before going into defining this term, it is important to keep in mind that when one talks about balance in human beings there are a few terms that keep coming up, like equilibrium, posture, stability, and balance itself. These terms however, are not always synonymous of each other.

Balance can be defined as the automatic and unconscious process by which a person maintains and moves his or her body in a specific relationship to the environment (Hobeika, 1999). Other authors like Daubney & Culham (1999) go a bit further and define balance in three different ways: the ability to maintain a position, the ability to be able to move voluntarily, and the ability to react to a perturbation. The last aspect (the ability to react to a perturbation) is very crucial and not always regarded when defining balance. Without this ability of reacting to an outside force that could interfere in one's balance one would easily loose balance. It is important to notice that without the sense of balance a person would not be able to resist the destabilizing effect of the gravity, or even to move purposefully and communicate effectively.

2.2.2. Balance and the elderly person

Decreased balance affects every elderly person; it is a result of the normal age-related morphologic changes occurring in all body systems, including the systems essential for the maintenance of balance. After the age of 60 every person experiences some degree of imbalance (Hobeika, 1999). In fact, imbalance can be said to be a part of the normal ageing process, but it is important to notice

what are normal age-related changes affecting the balance and what are not normal age-related changes that sometimes take place during the ageing process.

As it was mentioned before, the body relies on different receptors and sensors to obtain information, in order, to then be able to make the right adjustments and maintain balance. Age-related changes affecting these receptors and sensors will thus have an impact in the person's ability to maintain balance. Among all the normal age-related changes that take place during the normal ageing process, the ones that have the greatest impact in the elderly's sense of balance are: the diminution of primary vestibular neurons, loss of hair cells in the vestibular sensors, decreased neuronal cell density of the cerebral cortex, and a reduced amount of Purkinje's cells in the cerebellum. A good example of the degree to which these changes can affect negatively the balance of the elderly person is that, a person at the age of 90 usually has anymore only 20 to 35% of its initial cerebellum cells left (Hobeika, 1999).

2.2.3. Sensorial changes affecting the balance in the elderly

Besides the morphological changes, mentioned before, which have a direct impact in the sense of balance there are also other relevant changes taking place in the sensorial systems that play an important role in the balance sense. The sensorial systems playing an important role in the balance are, the visual, vestibular, and somatosensorial systems. It is not yet sure if the choices made when choosing one certain sensorial information, used for the control of balance, are made by any kind of hierarchy. By other words, it is not sure if information from one sensorial system has any type of priority over another information from another sensorial system (Aiken, 1995).

The visual system is the most complex system of all the sensorial systems. Changes in the visual system are a normal part of the ageing process; even a person that does not have or had any visual pathology will have lost 50 percent of the vision by the age of 80. Various changes occur in the different parts of the eye, changes that will have major repercussions. In the retina, decreases in its function begin to take place between the ages of 40 and 50 years and by 85 years usually only 25 percent of its normal function is left. The optic nerve also suffers changes; it looses some of its function and the time of impulse transportation increases (Kejonen, 2002).

The vestibular system plays an important task in maintaining the balance of the body and in coordinating the movements of the head and the body. This system has both a sensory and a motor function. The sensory function measures the head's angular velocity and linear acceleration and it is also able of determining the exact position of the head in relation to the gravitational axis. The motor function controls the muscular activity and also provides help in stabilizing gaze when the head and body are in motion. The vestibular organs responsible for the control of balance are placed in the labyrinth. The special receptor cells localized in these organs are able to translate movement into neural signs. As it was mentioned before, some of the most relevant age-related changes that occur during the normal ageing process take place in the vestibular system. They include a decreased neuronal cell density of the cerebral cortex, a diminution of primary vestibular neurons, and a significant loss of hair cells in the vestibular sensors (Kejonen, 2002).

The somatosensorial system is the one system that has a very crucial role in balancing. Its sensors are located in the skin, muscles, ligaments, tendons, connective tissues of the articulations, and internal organs. The receptors from this system that play the most important role in balancing are the sensors of touch and the sensors of position. This system has two types of sensors; they are mechanoreceptors and proprioceptive receptors. The first ones are the ones located mainly in the skin giving us the sense of touch. The second ones give us the sense of where is the body positioned in the space, at what intensity and in which direction it is moving. In addition, the greatest part of cells from the somatosensorial system has a selective sensitivity for only one of the following modalities, touch, pressure, temperature, and pain (Kejonen, 2002).

All these age-related changes affecting the elderly person’s ability to maintain balance have major impacts in the lives of elderly people. Problems with balance control not only make normal activities of daily living become more challenging but they also may lead to falls, and thus to numerous other problems, like disability and loss of independence.

2.3. The importance of maintaining an active lifestyle

2.3.1. Physical activities and the elderly person

Physical activity is defined by the World Health Organization (WHO) as "any bodily movement produced by skeletal muscles that requires energy expenditure" (WHO, 2009: Benefits of Physical Activity. p.1). So much has been written about physical activity and its benefits to the population. Several studies have shown that regular and moderate physical activity has innumerous benefits to the elderly population and to other age groups as well. Physical activity has in fact given proofs in many different studies that it can be an excellent tool to prevent and even fight some of the debilitating conditions often experienced in later life. Some of these conditions include cardiovascular disease, obesity, stroke, hypertension, high blood cholesterol, osteoporosis, and osteoarthritis among others. There is evidence that physical activity can have a positive effect in preventing and or controlling to some degree each of these conditions. As an example the WHO makes the following recommendation: "*Engaging in physical activity for at least 30 minutes on most days of the week will help to keep away heart attacks and strokes*" (WHO, 2009: Cardiovascular Diseases. p.1).

In general, physical activity has in fact some degree of influence in all the aspects usually mentioned as important for quality of life, especially in health, physical activity, mobility, safety and independence (Kell & Quinney, 2001). Although the importance of exercising in order to maintain general health and well-being is already known by most people, it has not yet been acknowledged by a whole lot of people. According to the WHO, the number of people failing to complete the recommended amount of physical activity required to induce health benefits is alarming, accounting at least 60 percent of the world's population. Also according to the WHO, the older adults are one of the high-risk populations for physical inactivity (WHO, 2007).

In addition, physical activity's beneficial effects for the older people go well beyond what can easily be seen. Physical activity can reduce the risk of falling, which is a major cause of disability among older people. This risk of falling reduces, as the older person's physical condition gets better. Improvements in aspects such as balance, strength, coordination and motor control, flexibility, and endurance are of great relevance for diminishing the risk of falling. Moreover, physical activity has also been shown to improve the mental health and cognitive function in older people, and even to

play an important role in the management and control of some conditions like depression and anxiety. The benefits of physical activity associated with mental health are often related to the fact that physical activity usually proportionate occasions to meet new people, maintain social networks, and socialize with people in general (Antunes et al, 2005).

2.3.2. Leisure time and the elderly

Leisure time is very beneficial for everyone, a way of escaping from the stress of work or studies, and clear one's mind while doing something one enjoys. In old age leisure time is even more important, in fact, leisure time benefits are recognized as an indispensable part of the relational life of elderly subjects (Di Mauro et al, 2001).

Leisure can be defined as "time free from the demands of work or duty, when one can rest, enjoy hobbies or sports, etc" (Leisure, 2007, p.1). One's successful adaptation to older adulthood is quite dependent in leisure activities practiced in early and middle adulthood. Leisure activities help promoting not only the elderly physical condition but also social interaction.

The popular leisure activities among the elderly people are changing all the time. The elderly people are no longer restricted to activities such as fishing, gardening, and golf. Although these activities are still popular among the elderly their preferences tend to change, and we can find a great number of elderly practicing and interested in activities like skiing, swimming, jogging, cycling, and volley ball, among others. A general understanding of the importance of leisure activities for the population, in particular for the elderly, is growing, resulting in the promotion of more and better opportunities for the practice of leisure activities, which is of great value.

2.4. The bicycle as an instrument for activating the elderly

2.4.1. The bicycle

The fast growing number of elderly people in relation to the number of younger people is an important topic at the moment. Different measures have started to be implemented including policies of active ageing with the aim of promoting the health and well being of the elderly population, avoiding major health care costs and others. As a safe way of exercise that it is, cycling should be given more attention as a way of enabling the elderly to exercise. According to a study conducted in Denmark, people who did not cycle to work had a 39% higher mortality rate than people who cycled to work, irrespectively of the level of other leisure time, physical activity and other factors investigated (Andersen et al, 2000).

In addition, a bicycle provides the elderly with the required mobility needed in almost all the day-to-day activities. Through the use of a bicycle the elderly persons that are no longer able to use safely a car or public transportation have the possibility of maintaining themselves independent in terms of mobility, not requiring the help of anyone to go from one place to another. With all this in mind, the only thing stopping a bicycle from not being a perfect tool to enable the elderly to keep active, and independent in terms of mobility is the lack of adequate vehicles available for this population.

2.4.2. Why cycling?

Cycling can be very beneficial for the elderly population as it was showed before, by being an efficient means of mobility and also a safe exercise tool, but cycling is not just beneficial for elderly persons. There are very many benefits that would result from leaving a car-dependent lifestyle. According to Sommer (2003) there are many benefits of increasing cycling's modal share. Some of the main benefits include economic benefits, social benefits, and environmental benefits.

Economic benefits; some of the most important economic benefits resulting from increasing cycling's modal share include:

- *Increasing the local property values.* More bicycle lanes, less pollution, less noise, all aspects that increase property values.
- *Less public money needed to create a high quality transportation system.* Constructing urban cycleway is much less expensive than constructing urban freeways.
- *Correlation with overall wealth.* There is a general compatibility of bicycling and a good economy. The reasons behind these are many; one of the main reasons is that excessive spending on cars and their infrastructures results in less money for the people and for the economy that can be used for productive things (Sommer, 2003).

Social benefits; some of the most important social benefits resulting from increasing cycling's modal share, according to Sommer (2003) include:

- *Improved personal finances.* Transportation accounts a very substantial part in family budgets, in the United States the second largest item in the average family budget. Some advantages of using more a bicycle than a car include, the price, a good bicycle costs about 2% to 3% as much as a car, the bicycle does not require fuel, nor insurance, and needs only minimal maintenance. In addition, the bicycle uses free parking places and its value may not depreciate at all.
- *Better physical and mental health.* Using a bicycle as a way of transport is an easy way of exercising and through this improve the physical health and prevent a wide number of diseases, including heart disease, the number one cause of mortality in the developed world. Moreover, bicycling develops balance, coordination, and strength; it also tones the body, burns calories, improves LDL and HDL readings, and strengthens the bones. In addition, exercise and contact with the nature are two therapeutic aspects for mental and emotional disorders.
- *Less obesity.* According to the WHO (2006), the obesity epidemic is among the top ten global health problems. Being obese increases the chance of developing a range of health problems, like heart disease, type 2 diabetes and arthritis. In order to prevent obesity, increased physical activity and a healthier diet are needed. Like others forms of exercising, cycling can help preventing obesity. According to Hillman (2000), cycling has been shown to produce significant health benefits, including weight loss and reductions in risk of mortality.

And highlighted the fact that the life years gained outweigh the life years lost in traffic accidents by 20:1. One of the advantages of cycling, in relation to other forms of exercise, is that cycling is not so aggressive to the joints. This is an important aspect to take into account, especially for overweight persons who want to exercise.

- *Greater Mobility.* Bicycles can be faster than cars especially in the cities. An example that proofs this fact was a race organized in New York by the Transportation Alternatives, an anti-car lobbying group. The race had three participants, a bicyclist, a car driver, and a subway rider. The race started in the Brooklyn area, and finished in the area of central Manhattan. The cyclists won taking 16,5 minutes to complete the distance, the driver made it in 22 minutes, the subway rider came in last place taking 29 minutes. Taking into consideration that this was a sidewalk-to-sidewalk race, meaning that the bicyclist did not have to lock up the bike and the driver did not have to look for parking place, the cyclist would have won by a even a large difference of time if the participants would have had to park their vehicles (Samponaro, 2007).
- *Inclusion of Senior Citizens.* The danger, emotional stress and liability that come with driving in metropolitan areas keep many senior citizens off the road who would probably be eager to go to work, visit friends, and exercise on bicycle trails.
- *More Equitable Living for Low-Income Earners.* During the years of 2005 and 2006, the percentage of money allocated for transportation costs by the Portuguese families accounted a total of 12,9% of their total income (Jornal de Notícias, 2008). Taking this into consideration, cycling can be an excellent way of diminishing the burden of the transportation costs. The bicycle can be an excellent alternative to the car or even to the public transports, with its purchase, depreciation, maintenance and parking costs being very accessible, even for the families with low incomes.
- *Individual Opportunities for Safer Travel.* In 2007 the number of road accidents with victims in Portugal was 35 311 and the number of driving fatalities was 854 (Instituto Nacional de Estatística). These are alarming numbers, cycling is a much safer way of moving around, especially when appropriate infrastructures are available for use.
- *More Resources for Public Use.* The costs behind implementing a good cycling infrastructure are much smaller than implementing any other transport infrastructure. According to Hillman (2000), when comparing the cost of construction of a kilometre of cycleway with other transport infrastructures, concluded that the cost for a bus priority route

is six times as high, for a light rail transit system is 200 times, for a motor way is 300 times, and for an underground metro system is 8000 times as high. Therefore, allocating funds in cycling infrastructures will bring large savings that can be allocated in other areas.

- *Less Congested Roads.* More cyclists mean fewer drivers, and fewer drivers mean less congested roads. A very important aspect especially in metropolitan areas. This will reduce travel times and with this improve quality of life.

Environmental benefits; some of the most important environmental benefits resulting from increasing cycling's modal share include:

- *Better Air Quality:* Driving a car is the most polluting action an average citizen commits (Alpha Online, 2008). Cycling does not generate any air pollution.
- *Less Noise.* Road traffic is by far the major source of noise. Cycling does not produce almost any noise at all.
- *Slowing the Pace of Global Warming.* The more cars there are on the streets, the more are carbon emissions that are driving global warming. Changing the cars for bicycles could for sure help slowing done the global warming process to some significant degree. A few governments have already acknowledged the importance of changing the car for bicycles in order to slow the pace of the global warming. An example of this is the Seoul city government, which has recently announced plans to build 207 kilometres of cycling paths, during the next four years, extending to all the corners of the South Korean capital. The city will also build bicycle parks at 16 subway stations, equipped with shower rooms and lockers for cyclists (AFP, 2008).
- More Sustainable Lifestyle. Using the bicycle instead of other ways of motor transport is a very good example of living a sustainable lifestyle. Governments in many countries have quite recently acknowledged this fact, and have started to implement campaigns to encourage cycling. In Portugal we have for example, the CP (Portuguese Trains company) allowing passengers to carry bicycles in urban and regional trains; and city bicycles in some cities like Aveiro. In Denmark they have had "bicycle to work campaigns" as a way of motivating people to use the bicycle as a regular way of transport (Pedersen, 2000). In England there are cycling campaigns in some of the major cities like London, where it is founded the "London cycling campaign", the largest urban cycling organization in the world. This organization offers their members a wide range of benefits including, discounts in

bicycle shops and beyond, cycling theft insurance, free third party insurance, and free legal advice on cycling matters (London Cycling Campaign, 2008). Also in England, there is a "cycle to work scheme" controlled by the government covering the whole country, it consists of a tax incentive aimed at encouraging employees to cycle to work, the basic idea is that employees make large savings on purchasing new bicycles, while employers get a healthier workforce and save money as well (Cycle Scheme, 2008).

2.5. Gerontechnology

Gerontechnology is a relatively new field. Jan Graafmans in Eindhoven coined the term Gerontechnology in 1989 to supplement the already existing term called "technology and aging". The term Gerontechnology is a combination of two words, gerontology and technology. Gerontology can be defined as the scientific study of ageing, and technology can be defined as the research, development, and design of new improved techniques, products and services. Gerontechnology was defined by Harrington & Harrington (2000, p.5) as "the study of technology and aging for ensuring good health, full social participation, and independent living throughout the entire life span, however much it may lengthen." In another definition given by Graafmans et al (1998, p.13) he states Gerontechnology as "the adaptation and development of products, services, and environments to the needs of an aging and aged population".

There are three very important concepts to Gerontechnology. The first is that development of the society is pushed by technological progresses, especially in the areas of communication, information and technology. If elderly are to be included in the society, technology should very strictly take them into consideration. The second concept is that age-associated differences in ambitions and in function affecting the elderly can be met through improvements in the technological environment. The third concept is that elderly persons should remain in control of their technological environment, by other words, have the possibility to decide what they want to be done automatically, and what they do not want to be done automatically (Harrington & Harrington, 2000).

Gerontechnology applications can be grouped into the *five major aspects of Gerontechnology*. They are enhancement, prevention, compensation, care, and research. Enhancement; in the way that

Gerontechnology is a way to help creating an environment where elderly people can develop their new ambitions. In this sense, Gerontechnology is a way of providing self-fulfilment and enrichment through new/different ways of activity or environment stimulation. Prevention takes place in the sense of preventing a problem from developing/occurring to the elderly person. An example of this could be a device to measure the heart rate while a person is exercising, this type of device allows the person to not go over his/her personal limits preventing a heart attack or other problematic conditions from taking place. Compensation occurs when prevention did not succeeded and a problem took place. In order to help the person cope with the problem, technology can provide compensation for it. An example of compensation could be a wheelchair designed to compensate a person for a walking disability. Care takes place in the way that Gerontechnology can help the care providers in taking care of the elderly. It is in this way a technology not so focused in the care itself but in supporting the persons who provide the care, including self-care. An example of this could be a device to help the care providers moving the elderly person in poor physical condition from a bed to a wheelchair, not requiring physical work from the care providers. Research is the last aspect and it is the one that takes all the other aspects into account. Research is a wide concept in this case meaning: research, development, and design. This aspect means the focus that Gerontechnology has in the research of the two fields, technologies and elderly people, and the will to find the better way to combine these two aspect together (Harrington & Harrington, 2000).

2.6. Quality of life in old age and mobility

Quality of life" is a very broad concept, which can be defined in many different ways. Although a lot of research has been conducted in this area in the past thirty years, there does not appear to be one generally accepted definition of quality of life (Treasury Board of Canada Secretariat, 2000). Maybe the most commonly stated definition of quality of life in the literature is the one given by the WHO. The WHO (1997, p.1) defines quality of life as “individuals’ perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns”.

Although not all researchers agree on a single definition of quality of life, there is agreement that quality of life is temporal and multidimensional. As far as research in the area of quality of life, one

distinction is usually made between the subjective and objective quality of life. “Subjective quality of life is about feeling good and being satisfied with things in general. Objective quality of life is about fulfilling the societal and cultural demands for material wealth, social status and physical well-being” (Quality of Life Research Centre, 2005, p.1).

Quality of life is a concept difficult to define, mainly because different people, value different things, by other words, it represents a unique/individual evaluation. This individual evaluation is made based on certain factors; according to Bowling (1995) the factors influencing the quality of life are dependent on the aspect age. Bowling (1995) states that younger people tend to give more importance to work and finances, while elderly people tend to consider health and mobility the most important factors playing a role in their quality of life. It is the aspect of age/time that plays a great part in making quality of life a dynamic concept, which represents great challenges for its measurement. Quality of life is made up of both, positive and negative experiences, and affect and values and self-evaluations of life may change over time in response to life and health events and experiences (Brown et al., 2004).

According to Bond and Corner (2004), although older people talk about quality of life in different contexts, the factors defining quality of life for this population group are likely to apply equally for younger age groups. There is no consensus in a definition of quality of life in old age; however, a few researchers have tried to list the aspects that the elderly persons most value in life. Smith (2000) in her study concluded that the aspects most valued by the seniors were health, social contact, family, activities, safe neighbourhoods, and having sufficient finances. According to Brown et al. (2004), although quality of life is inevitably subjective and based on individual perceptions, the most frequently reported empirical associations with quality of life in older age are good health and functional ability, a sense of personal adequacy or usefulness, social participation, the existence of friends and social support, and level of income or other indicator of socio-economic status. Bond and Corner (2004) came to the conclusion that the important components of a good quality of life are family (children), social contacts, health, mobility/ability, material circumstances, activities, happiness, youthfulness, and living environment. Although these aspects are all factors that could easily associated with quality of life in all ages, according to Paúl and Fonseca (2005), the aspect of health tend to be especially valued by the elderly people.

Besides the aspect health being usually more valued by older people than younger people (Paúl and Fonseca, 2005), these are not the only differences in the way quality of life is perceived by older people. According to Borglin et al. (2005), quality of life in old age depends from the preservation of the *self* and of the preservation of objectives throughout the whole life course. The way older people assess their quality of life is also different, older people quality of life assessment appear to be based on their expectations, which is very much connected to their life experiences and life biographies (Bond & Corner, 2004). According to a study developed by Borglin et al. (2005), the experience of quality of life in old age is associated with values of life, past experiences, ability to adapt to changes, independence, activity, health, social relations, and living at home. In addition, mobility is also an aspect that is often more valued by the elderly people and usually regarded as being a crucial contributor for a good quality of life (Whelan, 2006).

Mobility plays a great role in the quality of life, especially in old age, due to being a crucial element in allowing the elderly to live an independent life. Mobility is an aspect that has to some degree an impact in almost all of the factors associated with quality of life. Mobility is essential for general independence, as well as, ensuring good health and quality of life by enabling the seniors to have access to essential services, activities, and social contacts, as well as, fulfilling basic needs, independence and comfort (Oxley & Whelan, 2008). The increasing of age is associated with more susceptibility to immobility. Elderly people are more prone to live with multiple chronic health conditions; this may limit their mobility, which will result in a direct negative impact on their quality of life. In addition, without the possibility to maintain mobility, elderly persons cannot have an independent life, thus this could lead to tremendous results like isolation and health problems as a consequence (Haindl & Risser, 2006).

The importance of mobility in the quality of life of the elderly people covers a wide range of activity and operates at many spatial scales. According to Metz (2000), an adequate conception of mobility for the elderly should comprise 5 key elements, these are: travel to achieve access to desired places and people; the psychological benefits of “getting out and about”; exercise benefits; involvement in the community; and potential travel (knowing that a trip could be made if necessary or desired). This framing gives a clearer picture about the degree of importance that mobility represents in the lives of the senior citizens.

As it has been showed before, decreases in mobility can influence many aspects directly linked to the quality of life of senior citizens. One of these aspects is isolation, elderly people more than other age groups are susceptible to live with multiple chronic health conditions; this can limit mobility and thus further restrict their capacity to socialize (Hall & Havens, 1999). Having a personal network is a very important aspect in people's daily lives. People who are socially isolated tend to have lower quality of life, and also are less healthy than those who are embedded in a network of personal relationships (Machielse, 2006).

Personal networks play a great role in quality of life. There are three major functions in which personal networks influence the quality of life of seniors; they are identity and self-respect, social integration, and social support. Appreciation and recognition of others are essential elements for identity and self-respect, a personal network provides these two important elements. Social integration takes place through personal networks, as these offer people the possibility to feel part of a group where they can experience personal involvement, friendship and intimacy. Finally, social support is also a very important function of personal networks. The feeling of knowing that in times of need there is someone one can count for help and support is crucial for people's well-being and health (Machielse, 2006).

As it was showed, social isolation has negative effects in the functioning and well-being of older people, this as a consequence often leads to serious problems like depression or physical symptoms. In addition, social isolation can result in a situation of marginalization or social exclusion, signifying that people no longer see a way of taking part in the society. But social isolation does not only have a direct impact in the individual, it also has negative societal consequences. If in a society there are too many persons who do not take part in societal life, cohesion and solidarity are consequently affected. Moreover, people without social support in their close surroundings more often turn to formal/professional help than those that are in a social network. This phenomenon is therefore associated with high costs for the social healthcare system (Machielse, 2006).

Regarding all the facts showed before, it is obvious that the modern welfare states should improve the mobility of senior citizens, and by doing so contribute for the maintenance of quality of life. In conclusion, it should be common knowledge that most of the measures that improve the quality of life of senior citizens also bring benefits for many other citizens as well (Oxley & Whelan, 2008).

3. Study Aim

The main aim of this study was to validate the pertinence of building bicycles specifically designed for the senior population, while giving a continuation to the previously developed study, *Smartbike: A Vehicle for the Elderly*. For this some specific objectives were stipulated, they were characterize and get acquainted with the senior bicycles available in the market; obtaining concrete information about the seniors and senior bicycle users in Portugal; getting acquainted with the existing health promoting programs that use the bicycle as an instrument; and in addition, also developing a plan for the test of the future Smartbike prototype.

3.1. Research Questions

The research questions of the study are:

1. What are the experiences and opinions of the seniors and senior bicycle users in Portugal towards bicycles and cycling?
2. Which aspects do the seniors valorize in a senior bicycle?
3. What kinds of senior bicycles are available in the market?
4. Which features/characteristics are present in these vehicles, and how some of these features have an impact in the users?
5. What kinds of health promoting programs are using the bicycle as an instrument? How are these programs working?
6. How should the Smartbike future prototype be tested?

4. Theoretical Framework

The development of this study was based in two main principles. The first principle has its base in the theory of active ageing and the knowledge that a bicycle is an extremely valuable and safe tool for activating and promoting independence in the elderly person (Gardner, 1998). Active ageing is defined by the WHO as *"the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age"* (WHO, 2002, p.12). This process includes a changing of mentality and strategic planning from the "needs-based" approach, which assumes that older people are passive targets to a "rights-based" approach, which recognizes the rights of people to equal opportunities and treatment as they age (WHO, 2002).

The second principle has its base on environmental protection theories that enhance the use of a bicycle as a way of protecting the environment. Bicycles are emerging as a solution to some of today's worst urban problems, like air pollution, congestion, and dangerous streets. According to Gardner (1998), everything indicates that bicycles will become an integral part of urban transportation systems for the 21st century due to its benefits in terms of environmental, economical, and crime related benefits. An example of this fact is the fast growing number of cities, all around the world, which are implanting public bicycle systems or community bicycle programs. The first community bicycle program started in the 1960's and had its origin in Amsterdam, the Netherlands. After this success, other cities started to implement these programs as well. Nowadays, due to the so popular topic that is environmental protection, these programs are having even more interest. The main goal of these programs is to diminish the use of automobiles for short trips inside the cities and thus reduce the air-pollution, traffic congestion, and noise. As an example, just in Spain already about 30 cities implanted a public bicycle system, and this number tends to grow (Fundación ECA Global, 2007). In addition, according to a study conducted by the European Commission about promoting the use of the bicycle in the cities (Wallström, 2000) the environmental benefits of the bicycle use can go a lot further than it is possible to speculate.

In addition, it is relevant to make reference to one concept that should be defined to avoid misunderstandings. The concepts *senior bicycle* and *bicycle for seniors* are very often used in the present study, however, the term bicycle in this study regarding these concepts, does not necessarily mean "a pedal-driven, human-powered vehicle with two wheels attached to a frame, one behind the

other" (Bicycle, 2008, p.1). The term bicycle in the present study is used to make reference to pedal-driven, human-powered vehicles, not limiting the number of wheels to only two. Therefore, in this study the term tricycle is referred as "bicycle" because it is a pedal driven, human-powered vehicle.

5. Methodology

As it was mentioned in the introduction, the study is divided in four main parts, Review and Evaluation of the Existing Senior Bicycles in the Market, Survey on the Portuguese Potential Users of Senior Bicycles, Review of the Existing Health Promoting Programs That Use the Bicycle as an Instrument, and Planning of the Smartbike Future Prototype Test. Each of these parts focuses its attention in one specific objective of the study and together they aim at giving answer to all the stipulated research questions.

The first part, Review and Evaluation of the Existing Senior Bicycles in the Market, a document analysis which focused on characterize and get acquainted with what kind of senior bicycles are available in the market. The second part, Survey on the Portuguese Potential Users of Senior Bicycles, had the aim of obtaining concrete information about the potential future users of the senior bicycles in Portugal. The third part, Review and Evaluation of Existing Health Promoting Programs Using the Bicycle as an Instrument, focused on getting acquainted with the existing health promoting programs which use the bicycle as an instrument. And the forth part, Planning of the Smartbike Future Prototype Test, had the aim of planning a suitable test for the future Smartbike prototype.

Each of these parts has its own specific methodology; therefore, the methodology chapter is divided in four subchapters, covering each of these parts. In the end of the study, in the conclusions chapter, the results of the four parts will be reviewed with the intention of bringing up the most relevant conclusions. Furthermore, these four parts, that are sort of “sub-studies”, were thought to be the necessary “sub-studies” to be conducted in order to obtain the needed information to complete the pre-prototyping phase of the Smartbike study. Moreover, the forth part, Planning of the Smartbike Future Prototype Test, is already a supplement that will be part of the post-prototyping phase, or by other words, it will be useful in the testing of the Smartbike future prototype. In the end of the methodology chapter a study scheme was included, the scheme gives a clear overview of the whole study, which promotes an easier comprehension of the study organization.

5.1. Review and Evaluation of the Existing Senior Bicycles in the Market

In order to obtain a better general picture of what is being done in the field of cycling vehicles for seniors, the author decided to conduct a review and evaluation of some of the existing bicycles for the elderly already available in the market. For this review and evaluation, eight models of bicycles available in the market, which are specifically designed for elderly persons, were chosen. All the eight vehicles were found through the Internet, with the help of Google search engine. Although there is not that many models of bicycles available in the market specifically designed for elderly people, the author tried to find as many as possible, so that then a selection of the founded vehicles could be made. From this Internet search conducted, it was decided that the first 20 models to be found would undergo a selection. This selection was conducted taking into account the following criteria; primacy was given to the models that made a clear point that their target is elderly people, the models which had the most number of features designed specifically for seniors, and to the models that seemed to offer the most ergonomic cycling position. In addition, only models with detailed descriptions available were selected. This last criterion was the one eliminating most of the vehicles resultant from the search, as most of the vehicles did not have available a great part of the descriptions necessary for the review and evaluation.

Study Group: Vehicles Chosen for Evaluation

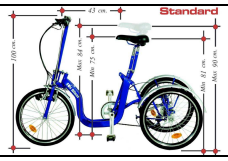
Model	Brand	Photo	Reference
1) R32	Di Blasi		http://www.diblasi.us/Folding_Tricycles.asp?Prd=R32&Pag=Prodotto&Lng=en
2) Carro	eZee		http://www.ezeebike.com/products/products_carro.htm
3) Top End Excelerator	Invacare		http://www.invacare.com/cgi-bin/imhqprd/inv_catalog/prod_cat_detail.jsp?s=0&prodID=XCL&catOID=-536885351
4) Trike	Helkama Bicycles		http://www.helkamavelox.fi/index.phtml?page_id=1117&navi_id=1117&10012_iProductId=%20HY3PN&10012_IPG:55_t=viewPublicProduct&
5) PAV3	Industrial Bicycles		http://www.industrialbicycles.com/pav3_trike.htm
6) Revive DX	Giant Bicycles		http://www.giant-bicycles.com/_upload_us/bikes/models/manual//ReviveManual.pdf
7) Senator	Helkama Bicycles		http://. www helkamavelox.fi/index.phtml?page_id=1117&navi_id=1117&10012_iProductId=HCS347&10012_IPG:55_t=viewPublicProduct&
8) EZ Roll Regal	Trailmate		http://rhrc.uark.edu/4537.htm

Table 1.

Document analysis was the chosen research method for this part of the study. One of the main reasons for this choice was that it is more practical and cost-effective than other research methods. As there are very few senior bicycles available in the Portuguese market, and it is very practical and accurate to read the vehicles' descriptions from their technical descriptions in the producers' website, this seemed like the most viable research method for reviewing the senior bicycles available in the market.

According to Deco Proteste (2006), the most important aspects to take into account when choosing a bicycle are, in first place, the frame and fork, then the brakes, gears, handlebars, pedals, saddle, wheels, suspension, and weight of the vehicle. According to the reviews comparing normal bicycles done in Deco Proteste magazine (2000), where 11 different models of mountain bicycles were compared, all of these aspects were taken into account when reviewing the different bicycles. With this said these were the parts also taken into account in the present review of the 8 models of bicycles for elderly.

The evaluation of the vehicles was conducted taking as a main standpoint the aspects regarded as important for a senior bicycle resultant from a study done by Spolander (2007). In his study Spolander (2007) held group discussions with elderly cyclists, and an expert seminar with participants from the cycle industry, design and ergonomics, research and public bodies, with the purpose of identifying the problems of current bicycles and the need for improvements. From Spolander's study (2007), 3 aspects stood out as the most important to take into consideration when designing bicycles for seniors. These aspects were easy boarding design, cycling position, and portability. In addition, for the present study, the aspect price was also taken into account for the evaluation, as it makes sense regarding the fact that in Portugal, like in many other countries, the elderly populations are at more risk of poverty than the working-age populations, and have a low purchasing power.

5.2. Survey on the Portuguese Potential Users of Senior Bicycles

With the objective of validating the pertinence of building bicycles specifically designed for the senior population and even with future ideas in mind of trying to find a bicycle company, which could be interested in commercialize the Smartbike, there was a need to gather information about the elderly persons, their perspectives and opinions. This information is of great relevance to understand the pertinence of building senior bicycles, as it is relevant to obtain information about potential future buyers of senior bicycles (persons which could be interested in buying a senior bicycle). It is fundamental for any enterprise, to do some kind of market research, first to determine which is the group of persons who will possibly be interested in buying/using their product, and then to collect as much detailed information as possible about these future potential buyers (Ribeiro, 2005). Understanding where the potential users are, what they are like, how they act, and what aspects in a bicycle they look for, will be essential to know how senior bicycles in general and the Smartbike in particular, could be accepted in the market. Once we have this information about our future potential users, we will have a greater chance of attracting those persons to purchase our product. Moreover, this information will also be essential for future upgrading of the Smartbike or to create a powerful marketing message in case the Smartbike will ever be commercialized.

The objective of this research was not specifically to enquire the potential users about their opinions on the Smartbike, but to gather concrete information about their experiences, preferences and interest on using a bicycle, and or towards bicycles.

5.2.1. Sample

It was decided that those 65 years old and older would be inquired, since those under 65 would not yet probably consider buying a vehicle intended for elderly people. Within the target group there could be made a distinction between two different groups, those who bicycle and those who do not bicycle. Therefore, two different structured interviews were planned, one for each of the groups.

The total number of subjects to inquire was set to 40 persons, consisting of 20 subjects who do not bicycle and 20 subjects who bicycle. It could make sense to inquire more subjects, but due to

difficulties finding a larger number of subjects who bicycle, this number had to be cut shorter. As far as inclusion characteristics of the subjects, it was also decided that the group of subjects who do not bicycle would consist of 10 women and 10 men. As for the group of those who bicycle, it was decided that this would not be convenient, due to the number of women aged 65 or over who cycle being extremely small and difficult to find. Thus, the subjects in this group were picked randomly not taking into account their gender. In addition, the subjects were picked in two different locations, in the city of Porto and also in the village of Murtosa.

All the subjects were picked randomly. Those who do not bicycle were picked in the central area of the city of Porto, and those who bicycle were picked in two different "strategic" locations. The first location was the Parque da Cidade in Porto, a popular place where people usually go cycling, jogging and walking, and the other location was the village of Murtosa, a place quite known for its large number of people cycling. At first it was thought that the data could be all collected in the city of Porto, but due to difficulties finding a large enough number of older cyclists, a second location had to be picked. The data collecting process was made in 5 days, where 4 days where spent in the city of Porto and one day in the village of Murtosa.

The subjects who do not bicycle where easy to find, and they were all inquired in 2 afternoons in the city of Porto. However, the subjects who bicycle where a bit harder to find, in 4 days in the city of Porto only 8 subjects who bicycle where enquired, while in the village of Murtosa all the remaining 12 subjects were enquired in just one day.

It is relevant to make reference to the fact that the information the author was willing to gather from one group, was not exactly the same as the information from the other group.

Group 1

Those who do not bicycle: From this group the main goals were to find if the subjects ever bicycled or why they stopped bicycling; if they would consider start riding (again) in case they had a bicycle that fulfills their needs as cyclists; if they are acquainted with the existence of senior bicycles, and if they would ever consider buying a senor bicycle.

Group 2

Those who bicycle: From this group the main aims were to find which are the reasons why they bicycle, how often they bicycle, if they are acquainted with the existence of senior bicycles and if they would ever consider buying a senior bicycle.

In addition, both sample groups were enquired to rate which aspects they consider most important and least important in a senior bicycle.

5.2.2. Instruments

For this purpose it was decided that a structured interview would be the most appropriate instrument to use, mainly due to its easy and fast application. At first it was thought that a questionnaire could be more practical to apply, but during the validation process it was easy to notice that this would not work so well, mainly due to the fact that it is not easy to stop people while cycling and then make them fill a questionnaire.

As the main aim of this structured interview was to gather concrete information about the future potential users of senior bicycles in general, and the Smartbike in particular, and senior bicycles are intended to be used mainly by elderly persons, it was very clear that this would be the target group.

As the instrument was planned to be applied in two distinct groups, *those who bicycle* and *those who do not bicycle*, and with the purpose of collecting different information from each group, it was obvious that two different structured interviews would be required. Furthermore, the interview planned for *those who bicycle* accounted 10 questions, and the interview planned for *those who do not bicycle*, accounted 9 questions.

5.2.3. Validation of the Structured Interviews

In order to validate the structured interviews, each structured interview was applied to 10 different subjects from each group, fulfilling the required characteristics of inclusion from the respective group. All the validation tests were conducted in the area of Porto city. From these 20 tests it was found that a few questions needed to be reformulated for better understanding. As both the interviews are quite small, the time for answering was not a problem. The inquiries were able to answer to all the questions in less than 4 minutes.

The major problem encountered during the validation process, and also during the data collecting process, was the fact that the respondents were suspicious about the two questions concerning their interest in buying a senior bicycle. Although it was explained to all the respondents the aim of the study and the aim of the interview, some of the respondents still were suspicious about these questions. It seemed that in the respondents' idea, the interview could be some sort of scheme to try to sell them a bicycle. This could probably have affected their responses to these questions. In other words, it seemed that although some of the respondents demonstrated interest in senior bicycles, when enquired about whether they have ever thought of buying such kind of vehicle or would ever consider buying such kind of vehicle, they immediately answered "no". This aspect was especially noticeable in some of the interviews conducted to the subjects that do not bicycle. Where some of the subjects answered that they would consider starting to cycle again if they had a vehicle that could fulfill their needs as cyclists, but then they answered that they would never consider buying a bicycle specifically conceived for seniors. This is a contradiction.

Overall, both interviews are quite straightforward and no serious problems were encountered other than the one above mentioned. For this problem, the only consideration that was taken into account more carefully was to try to ensure that the respondents understood the aim of the study and the purpose of the interview, however, as it was mentioned, a few people still seemed some how suspicious about it.

5.2.4. Data analysis

The data collected was analyzed with the help of SPSS (Statistical Package for the Social Sciences) version 16, a computer statistics program.

5.3. Review and Evaluation of Existing Health Promoting Programs Using the Bicycle as an Instrument

As it was already demonstrated before, the bicycle can be an efficient and safe tool for activating the elderly, and with this promote their health. Especially in the more developed countries, there are programs aimed at maintaining the elderly segment of the population active, and through this, help them acquiring active lifestyles which will enable them to maintain their independence and improve their quality of life. These programs usually include exercise activities like walking, gymnastics, swimming, balance exercises, water-gymnastics, yoga, and Thai-chi. Although some of these programs include multiple exercise activities and may even include cycling, this is not an activity typically included in the programs aimed at the elderly for health promotion.

With this fact acknowledged, the author decided to conduct an Internet search in order to try to find programs that focus their attention on the bicycle as a health promoter for the elderly persons. Finding how these programs function, their aims, and outcomes acquainted this study with substantial information about the viability of developing bicycles aimed at the elderly. Moreover, this survey gave us concrete information about the elderly persons' subjective perspectives towards cycling, and towards the use of a bicycle as a health promoter.

As the health promoting programs are usually programs conducted not in an academic context but in a general context, the search of these programs was conducted using solely the Google search engine. The following keywords were used in the search, "bicycle program", "health promotion", "elderly", "old people", "tricycle", "seniors", "riding program", "bike program", "exercise", "physical activity", "bike", "project", "cycling", "cycling program". These keywords were combined in several different combinations. In addition, also the same terms were used in Portuguese and Finnish language.

5.4. Planning of the Smartbike Future Prototype Test

The actual plan of the prototype test will be present and explained further ahead in the results chapter, however, in this subchapter its structure is presented and a brief introduction to it is made. The planned test is divided in two parts, a technical part, in which the strength, stability, and braking system of the Smartbike will be tested; and a usability test, in which a study group will be experimenting the vehicle. The technical part of the test is very straight forward, as it is based on wheelchair test methods from the International Standards Organization (ISO) (Cooper and Cooper, 2004), however, the second part of the test, the usability test, is more complex. Until the present moment, there is no literature available in the specific subject of testing bicycles or tricycles designed for the elderly. As the author thought it would make sense to have the actual future users involved in the prototype testing, there was a need for planning a course that would allow the users to experience the prototype.

After doing a literature search on the specific subject, one course was found, the White's *Bicycle Skills Course Instruction Manual* (1999). It seemed like this skills circuit, if adapted, could be used by a tricycle. After a few modifications, and with a course ready to be used by the study subjects, the next step was to plan how to evaluate the future Smartbike prototype. For this two instruments were planned, a semi-structured interview with the study subjects, and an observation form that focuses its attention in the vehicle performance in the circuit. The interview will allow the study subjects to express their opinions, and subjective perspectives towards the future prototype; and the observation form will evaluate the future prototype performance when being used by the study subjects.

5.4.1. Technical test

The technical test is based on the wheelchair test methods from the International Standards Organization (ISO) (Cooper and Cooper, 2004) and is divided in 3 parts, stability test, strength test, and braking test. The braking test is an extra test that although it is not based in the ISO test, it was thought to be necessary since, it is extremely important to ensure that the braking system works properly.

5.4.2. Usability test

The usability test, as it was mentioned before, will be conducted with the help of a circuit based on the White's *Bicycle Skills Course Instruction Manual* (1999) with a few changes made to the original White's circuit. The planned circuit has 7 different obstacles recreating realistic situations able to test the riding ability necessary to cycle in the street traffic. While cycling through this course, the study subjects will acquire the necessary experience for expressing their opinions about the Smartbike prototype. The subjects' performance with the Smartbike will be recorded with a video camera. This will allow the author to carefully examine the subjects' performance later and make its systematic evaluation.

5.4.2. A) Instruments for evaluating the usability test

In order to be able to evaluate the usability test, two instruments were developed, an observation form and a semi-structured interview. The observation form will focus on the performance of the vehicle throughout the 7 different obstacles encountered in the planned circuit. And the interview has the aim of obtaining the opinions, and subjective perspectives of the study subjects towards the Smartbike future prototype, as well as, the difficulties and or benefits they encountered while using the Smartbike prototype.

The observation form, as it was mentioned before, will be focused on the prototype performance while going through the 7 different obstacles. A few questions where planned for each obstacle, these questions will therefore concentrate on the prototype performance on each specific obstacle. Although the vehicle performance on the circuit is dependent on the subjects' own performance, these planned questions take an approach that attempts to judge the prototype, taking into account the subjects' performance. In addition, the observation form will be applied based on the footage captured during the test day.

The interview begins with 7 questions about the subject's background and lifestyle, followed by 14 questions regarding the Smartbike. These 14 questions will be aimed at obtaining the users' opinions and subjective perspectives towards the Smartbike prototype. These questions will be focused on finding which aspects the users, based on their personal experience in the circuit, liked and which

aspects the users disliked in the Smartbike future prototype, as well as, their fears and personal opinions towards the vehicle. These 14 questions focus on 3 very relevant aspects for a senior bicycle, comfort, cycling position, and easy boarding design. Furthermore, the interview has not yet been validated due to the fact that the prototype is not yet available.

The crossing of results from the two instruments will probably give a clear picture of the positive and negative aspects in the prototype, which will contribute for an adequate validation of the Smartbike future prototype.

5.5. Study Scheme

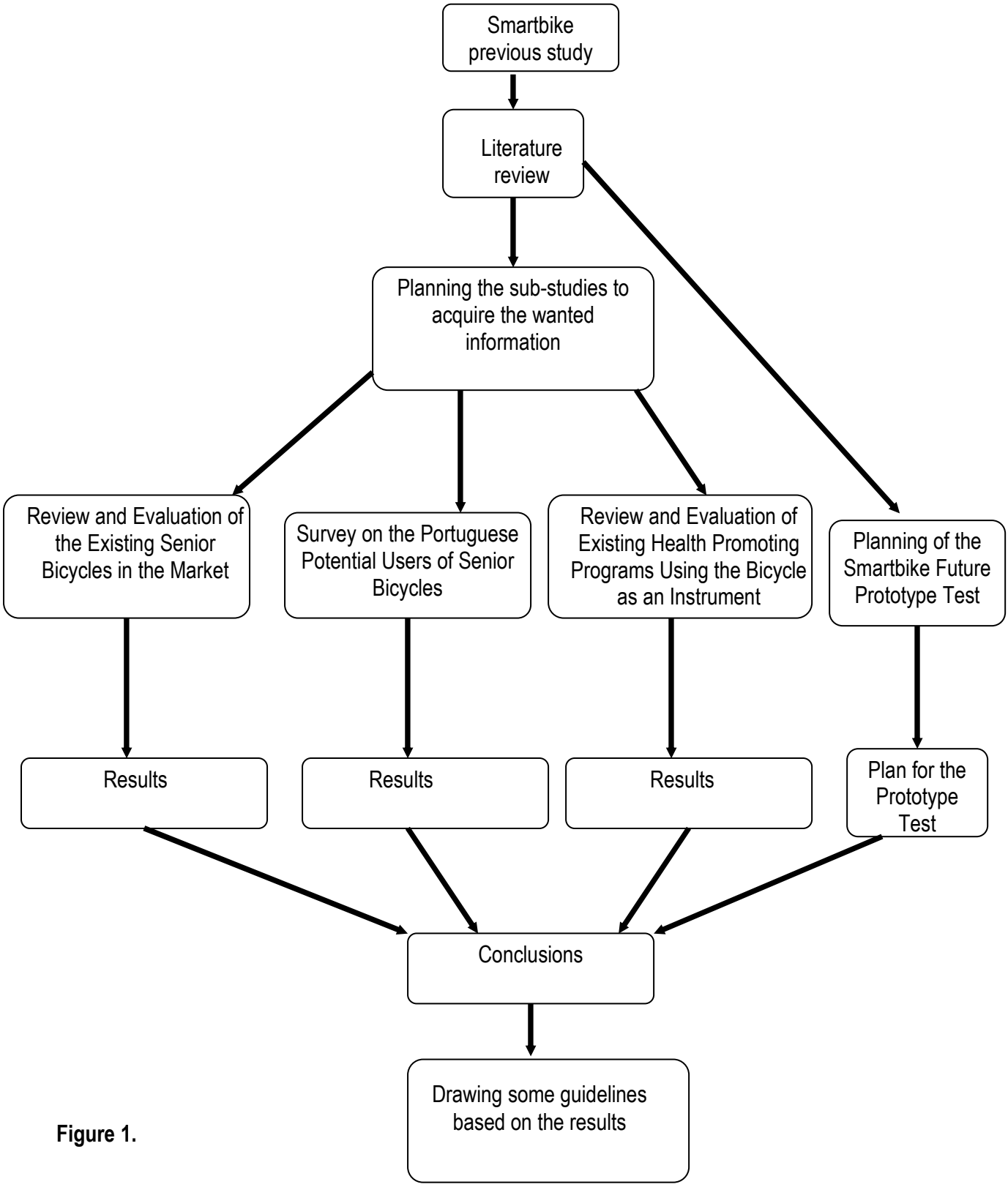


Figure 1.

6. Results

6.1. Review and Evaluation of the Existing Senior Bicycles in the Market

The bicycle has kept its fundamental geometry since the end of the 19th Century. This has negative remarkable repercussions on its comfort and safety. The same riding position has been retained putting stress on the arms, hands and buttocks, and the fall height is high. One of the reasons behind this is the fact that the bicycle design has been inhibited by tight international rules laid down in 1934. These rules originally applied to competition bicycles, but ended up setting the frame geometry design in stone for all the bicycles, and it was not until recent times that this trend has started to see some changes. Due to this, the riding position has for long been stuck within tight margins, resulting on the detriment of comfort and safety.

The number of bicycles designed specifically for older people available in the market is quite small. Until now the cycling companies have not invested much in designing vehicles specifically for the elderly. However, there seems to be a tendency for this to change. The number of bicycle companies that just design for the elderly or people with disabilities is very small, but the “normal” bicycling companies are starting to develop bicycle models for the elderly.

As the number of elderly persons is growing at a fast rate, so is the number of elderly persons who are interested in cycling and willing to exercise and keep active. Most of the existing vehicles aimed at the elderly available in the market are not integrally designed targeting the elderly person. This means that most of these vehicles have one or two parts that where designed for the elderly, like the frame or the saddle, but not all the parts were taken into consideration. This results in vehicles that do not really go towards the elderly person’s needs and limitations. Some of the most relevant design developments and features already existing in the market aimed at the elderly people include: tricycles, four-wheel cycles, better padding on handgrips, assisting electric motors, saddles padded with compressible gels, easy step-in frame design, and shock-absorbing seat posts. These are all features that make riding a bicycle easier, more comfortable, and pleasant, not only for elderly people but to everyone in general (Furchgott, 1999).

Before going into reviewing the vehicles, a brief introduction of each of the 8 selected vehicles is made, along with one photo of each of the vehicles, and a table with detailed descriptions of the components that complete each of the vehicles. After presenting all the vehicles, an evaluation of the vehicles is presented taking as a main standpoint 4 aspects regarded as very important for a senior bicycle. These aspects are easy boarding design, cycling position, portability, and price. The vehicles are evaluated and compared taking these four aspects into consideration.

6.1.1. Selected vehicles

Model 1: R32
Brand: Di Blasi

Introduction:
The model R32 is a foldable tricycle, the frame design is patented, it has a three-dimensional automatic folding mechanism, which allows the vehicle to be folded to the dimensions of a bag, in 5 seconds and with 3 simple steps, without using tools and without screwing or unscrewing any device (Di Blasi, 2008).

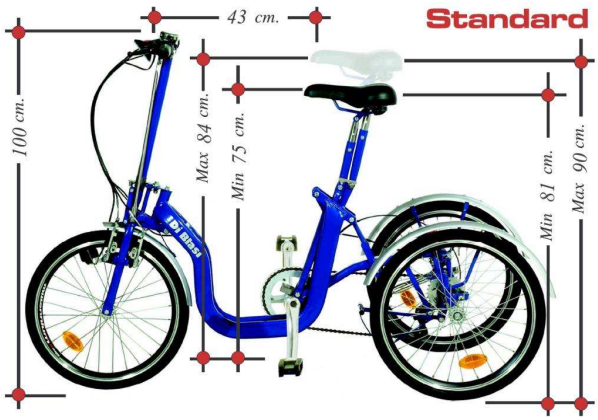


Figure 2. (Di Blasi, 2008)

Components

Parts	Dimensions	Descriptions
Frame	Front frame: 14cm from the ground	Easy boarding design. Fast folding system.
Fork	n.a.	No suspension
Speeds	n.a.	5 speeds. 5 sprockets in the back varying between 14-28 teeth. A chainring with 42 teeth. *Change speed system*: derailleur with freewheel
Brakes	n.a.	Two V-brakes in the front wheel
Wheels	48 cm	Wheelbase: 100cm Track: 66cm
Pedals	n.a.	Plastic Foldable
Lights	n.a.	In the front and back
Rack:	28x20cm	Maximum load: 10kg
Saddle	n.a.	Padded, with suspension. Height from the ground: 90/85,5/81 Height from the pedal in the lowest position: 84/79,5/75
Handlebars	n.a.	Straight design. Height from the ground: 100

Table 2.

Complete vehicle

Weight (kg)	21,4
Width (cm)	69,5
Maximum load (kg)	100
Dimensions when folded (L x w x h) (cm)	68, 28, 62,5
Price (€)	1075

Table 3.

Model 2: Carro

Brand: eZee

Introduction:

The Carro is an electric tricycle with a lot of luggage place, which offers the possibilities of being pedaled like a normal tricycle, ridden solely on electric power, or a combination of electric power and pedaling (Ezee Bike, 2008).

Figure 3. (Ezee Bike, 2008)

Components

Parts	Dimensions	Descriptions
Frame	n.a.	Easy step-in-and-over. Aluminum alloy 7005 T6
Fork	n.a.	Aluminum Alloy
Speeds	n.a.	7 speed, Shimano Nexus Internal.
Brakes	n.a.	Front: V-break. Rear: Shimano roller brakes. Tektro brake lever with electric shut off. Parking hand brake.
Handlebars	24" width	High handlebars Aluminum alloy
Wheels	20" diameter	Weinmann DH 39 twin wall CNC sides. Puncture resistant tires.
Pedals	n.a.	Plastic
Saddle	n.a.	Extra wide, with suspension. Seat post with suspension, steel.
Rack	n.a.	Large
Lights	n.a.	Built in lights. Powered by dynamo.
Motor	n.a.	Brushless, 350/700 watt peak front hub motor

Table 4.

Complete vehicle

Weight (kg)	33,5
Width (cm)	75
Height (cm)	104
Motor specs	Speed: 10 mph Range: 20 miles (subject to rider, terrain, etc.) Hill climbing: Strong
Maximum load (kg)	n.a.
Length (cm)	67 inches
Price (€)	1802

Table 5.

Model 3: Top End Excelerator

Brand: Invacare

Introduction:

The Excelerator is a stable and maneuverable upright three-wheel handcycle capable of reaching speeds up to 15 miles per hour (Invacare Corporation, 2008).

Figure 4. (Invacare Corporation, 2008)

Components

Parts	Dimensions	Descriptions
Frame	1 3/4" x .065 ovalized carbon steel tubing	Upright style with pivot steering. Adjustable fore/aft seat position system. Adjustable crank height and footrests.
Fork	n.a.	n.a.
Speeds	n.a.	7 standard gears and 7 low gears with the mountain drive option. 7 speed, Shimano Nexus Internal. Fully adjustable chain tension idler. Easy-to-reach 7-speed shifter.
Brakes	n.a.	Hands-on reversing drum brake.
Handlebars	n.a.	Handlebars with adjustable crank height.
Wheels	24 inch	Gears hub in the front wheel
Pedals	n.a.	Delrin or foam covered ergonomic hand pedals.
Saddle	Width: 14", 16", 18" or 20". Depth: 15".	Adjustable tension seat upholstery. Wide and cushioned. Back angle: 90 degrees Back angle: adjustable 11" to 14".
Rack	n.a.	n.a.
Lights	n.a.	n.a.
Motor	n.a.	n.a.

Table 6.

Complete vehicle

Weight (kg)	22
Width (cm)	n.a.
Height (cm)	Seat to floor height: Front seat height is 20" with 2" cushion (included). Rear seat height is 18".
Motor specs	n.a.
Maximum load (kg)	159
Length (cm)	165
Price (€)	1572

Table 7.

Model 4: Trike

Brand: Helkama

Introduction:

The Trike model is a steady easy-to-ride tricycle with a patent frame with a hinge, making it possible to adjust the front frame into a narrower position (Helkama Velox, 2008).

Figure 5. (Helkama Velox, 2008)

Components

Parts	Dimensions	Descriptions
Frame	Height: 47cm The front part of the vehicle is 102 cm in riding position and 78 cm when folded.	Easy boarding design
Fork	n.a.	Two forks that are steered at the same time.
Speeds	n.a.	3 Speeds. Shimano 3 v
Brakes	n.a.	V-brake and a Hub Roller brake.
Handlebars	n.a.	n.a.
Wheels	20”	n.a.
Pedals	n.a.	Plastic
Saddle		Wide, padded, with suspension.
Rack	n.a.	Classic rack.
Lights	n.a.	One halogen light on each front wheel and a backlight. Powered by dynamo.
Motor	n.a.	Optional

Table 8.

Complete vehicle

Weight (kg)	25
Width (cm)	102 in riding position and 78 when folded.
Height (cm)	n.a.
Motor specs	n.a.
Maximum load (kg)	n.a.
Length (cm)	n.a.
Price (€)	1450

Table 9. Description of the Trike

Model 5: PAV3 (Personal Activity Vehicle 3)

Brand: Industrial Bicycles

Introduction:

The PAV3 is a tricycle that incorporates a contemporary style with classic proven features.

Its semi-recumbent design offers a relaxed riding position to the cyclist (Industrial Bicycles, 2008).

Figure 6. (Industrial Bicycles, 2008)

Components

Parts	Dimensions	Descriptions
Frame	n.a.	Semi-recumbent design. Sliding seat track.
Fork	n.a.	n.a.
Speeds	n.a.	3 Speed
Brakes	n.a.	Back: Coaster brake. Front: Drum brake with a locking parking hand brake lever (integrated in the hub).
Handlebars	n.a.	Extra long
Wheels	Front 20”, back 24”	Thick rims Thick spokes: 11g Rear axle is 7/8" steel and machined
Pedals	n.a.	Plastic
Saddle	n.a.	Easy to adjust(no tools required). Padded. High backrest. Fold down armrests.
Rack	21x15x9 inches	Rear carrier basket
Lights	n.a.	n.a.
Motor	n.a.	n.a.

Table 10.

Complete vehicle

Weight (kg)	n.a.
Width (cm)	80
Height (cm)	n.a.
Motor specs	n.a.
Maximum load (kg)	227
Length (cm)	193
Price (€)	675

Table 11.

Model 6: Revive DX

Brand: Giant Bicycles

Introduction:

Revive is a bicycle centered on the aspect of comfort it offers a neutral riding position and adjustability for riders from 5'-6'6" (Giant Bicycles, 2007).

Figure 7. (Giant Bicycles, 2007)

Components

Parts	Dimensions	Descriptions
Frame	n.a.	Easy boarding design. Monorail one-touch micro-adjustable saddle
Fork	n.a.	Steel unicrown
Speeds	n.a.	7 speeds. Shimano Nexus 7-spd Twist. Twist-shift gear shifters
Brakes	n.a.	Back, Shimano Nexus Roller Brake. Roller brakes
Handlebars	Multi-adjustable	Special handlebar-stem, which is adjustable both forward and backward, and up and down. Alloy
Wheels	20”	Alloy, 28 spokes, puncture resistant tires
Pedals	n.a.	Plastic platform
Saddle	n.a.	Wide, cushioned, with adjustable lumbar support
Rack	n.a.	Rear alloy rack
Lights	n.a.	n.a.
Motor	n.a.	n.a.

Table 12.

Complete vehicle

Weight (kg)	23,6
Width (cm)	n.a.
Height (cm)	Adjustable
Motor specs	n.a.
Maximum load (kg)	n.a.
Length (cm)	n.a.
Price (€)	700

Table 13.

Model 7: Senator

Brand: Helkama Bicycles

Introduction:

The Senator is a bicycle with a very classical look but with a frame design specifically designed to facilitate the action of mounting or dismounting the vehicle, requiring the user to lift his leg only 15 centimeters in order to be able to mount or dismount the vehicle (Helkama Velox , 2008).

Figure 8. (Helkama Velox , 2008)

Components

Parts	Dimensions	Descriptions
Frame	Height, 47 cm	Easy boarding design
Fork	n.a.	n.a.
Speeds	n.a.	3 speeds. Shimano Nexus 3 v
Brakes	n.a.	Back, Shimano Nexus Roller Brake. Front, V-brake
Handlebars	n.a.	n.a.
Wheels	26”	Alloy
Pedals	n.a.	Aluminum
Saddle	n.a.	Wide, cushioned, and with suspension
Rack	n.a.	Rear alloy rack, front basket rack
Lights	n.a.	n.a.
Motor	n.a.	n.a.

Table 14.

Complete vehicle

Weight (kg)	18
Width (cm)	n.a.
Height (cm)	n.a.
Motor specs	n.a.
Maximum load (kg)	n.a.
Length (cm)	n.a.
Price (€)	599

Table 15.

Model 8: EZ Roll Regal

Brand: Trailmate

Introduction:

The EZ Roll Regal is a tricycle with a classical look, which has a multi-adjustable frame allowing a better fit for people with different heights (Trailmate, 2008).

Figure 9. (Trailmate, 2008).

Components

Parts	Dimensions	Descriptions
Frame	Height, 47 cm	Adjustable frame for a custom fit
Fork	n.a.	n.a.
Speeds	n.a.	3 speeds, coaster hub
Brakes	n.a.	Front, V-brake; back, coaster brake
Handlebars	n.a.	n.a.
Wheels	24”	Skyway mag wheels
Pedals	n.a.	Plastic
Saddle	n.a.	High-back tractor-style seat, cushioned
Rack	n.a.	Rear large basket
Lights	n.a.	n.a.
Motor	n.a.	n.a.

Table 16.

Complete vehicle

Weight (kg)	29,5
Width (cm)	71
Height (cm)	109
Motor specs	n.a.
Maximum load (kg)	113
Length (cm)	188
Price (€)	315

Table 17.

6.1.2. Evaluation of the vehicles

In order to be able to evaluate and compare the chosen vehicles, and through this withdraw some concrete and useful data, it was decided that the evaluation would be conducted regarding four very relevant aspects for a cycling vehicle designed for elderly persons. These four aspects are easy boarding design, cycling position, portability, and price.

6.1.2. A) Easy boarding frame design

As far as safety, the easy boarding frame design is probably the aspect that plays the most important role in a senior bicycle. This aspect all by itself can play a very significant role in avoiding accidents. In fact, one in five cyclists aged 65 and more injured in cycling accidents did so in connection with mounting or dismounting from the bicycle, and from these almost half of them were admitted to hospital (Spolander, 2007). The action of mounting and dismounting a bicycle is a great responsible for hip and femoral fractures, accounting a total of 40% of this type of fractures. The reasons given by the senior cyclists for this type of accidents included tripping, mounting wrongly, catching on clothing, and losing balance. In addition, Spolander (2007) in his study stated that an improvement in cycle design to make mounting and dismounting easier would be of great value. Taking these facts into account, it is easy to understand why the aspect “Easy boarding frame design” was chosen as one important aspect to examine in the chosen vehicles.

Comparative analysis

All the vehicles chosen when compared with a conventional bicycle have a very low step-through, which facilitate the action of mounting or dismounting. However, within the frame design from the chosen vehicles some frames have a more "easy boarding design" than others. From the 8 chosen vehicles one can quite easily divide them in two groups, those with "relatively easy boarding design" and those with "very easy boarding design". This distinction makes sense to realize, since the design of all the chosen vehicles have taken into account the easy boarding aspect much more seriously than the conventional bicycles. This distinction will allow an analysis of the vehicles within each group, making the comparison more logical.

The group of those with "relatively easy boarding design", comprising the vehicles with a design that although takes into account the boarding aspect, still do not offer a very simple way of mounting or dismounting the vehicle includes, the Top End Excelerator, the PAV3, the Revive DX, and the EZ Roll Regal. All these vehicles have a "medium high" step through, requiring from the cyclist the ability and balance to lift one of the legs higher than usually needed in normal activities of daily living. Looking closer at each of the vehicles, this problem is more marked in the Revive DX, since it is not a tricycle but bicycle, requiring from the cyclist the extra effort of holding the unstable vehicle during the boarding process. Both, The PAV3 and the EZ Roll Regal, have a very similar frame boarding design. The main advantage of the PAV3 is the fact that this vehicle is equipped with a parking hand brake, which facilitates the boarding process, as the cyclist can support himself in the vehicle, thus requiring less balance skills, and making the process safer. On other hand, one disadvantage encountered in the PAV3 is its extra-long handlebars that are an obstacle to the boarding process, as they block to some extend the usually empty space existent between the saddle and the stem. Concerning the Top End Excelerator, this vehicle also has a similar frame boarding design as that of the PAV3 and the EZ Roll Regal, and like the EZ Roll Regal it is not equipped with a parking handbrake, which as it was explained can make the boarding process less safer.

The group of those with "very easy boarding design" comprises all the other four chosen vehicles. All these vehicles have a design that does not require the cyclist to elevate his leg higher than around 20 centimeters from the ground, the equivalent to the height of a regular step. With all these vehicles

offering a very low step-through, it is other aspects that make the difference between the level of difficulty involved in mounting and dismounting each of these vehicles. The Senator is the vehicle that outstands of the group due to the fact of not being a tricycle, this as it was seen in the previous group might difficult the process of boarding. As for advantages, the Senator has a frame that does not only offer a very low step-through but also it has a simple design that offers a lot of free space, making the process of boarding quite easy.

One feature that also contributes to a better "easy boarding design" is the height of the seating position. Usually vehicles with a small wheel size (24 inches or less) offer a safer low seating position, and thus a better "easy boarding" (Spolander, 2007). Within these four vehicles, only the Senator has a wheel size superior to 24 inches, the other 3 vehicles are all equipped with 20 inch wheels. The Senator with its 26 inch wheels offers a relatively high cycling position, which may difficult the boarding process to some degree, especially for the smaller persons.

One other feature that can promote a safer process of mounting and dismounting is the handbrake. Within this group, only the Carro is equipped with such a feature. Thus, it seems as this vehicle could be appointed as the vehicle with the best easy boarding design, as it comprises three important aspects for a safer boarding process, a low step-through, a handbrake, and a low seating position.

6.1.2. B) Cycling Position

Conventional bicycles often have the saddle positioned higher or as high as the handlebars. This type of setting promotes a more or less forward-leaning cycling position, which has benefits in terms of air resistance. However, the negative points of this are that this position is not particularly comfortable or safe for the cyclist. As far as comfort, this cycling position results in stress to the hands, arms, shoulders, neck, and buttocks. And concerning safety, it has two negative effects, one is the fall height, and the other is exposure of the head in case of accident. These two negative effects can be eliminated with a lower cycling position, reducing the fall height, combined with a more up-right reclined cycling position, reducing the head exposure in case of accident (Spolander, 2007). An up-right cycling position also has advantages in case of strong braking, as there is not such a great risk of flying over the handlebars as there is with a "normal cycling position". Going back to the

comfort problems of a leaning-forward cycling position, these problems would almost be eliminated if the leaning-forward cycling position would be changed to an up-right cycling position.

Furthermore, a high cycling position makes the action of stopping/starting difficult, as the cyclist is forced to get off the cycle or leaning the bicycle over at a stop, in order to support oneself on one leg, and then starting off again as normal. According to the elderly cyclists inquired in the Spolander's study (2007), this action would be more comfortable and simpler if it would be possible for the cyclist to stay seated in the saddle with both feet on the ground when stopped. Regarding these facts, it seems that the ideal cycling position for an elderly cyclist would be a low up-right and a bit reclined cycling position.

Comparative analysis

The cycling position is influenced by a few aspects, like the height of the saddle, the height of the handlebars, the relation between the heights of the handlebars and the saddle, and the position of the cranks in relation to the saddle. By other words, the cycling position is very much influenced by the relation between the heights and positions of three parts the saddle, the handlebars, and the cranks. Furthermore, the type of saddle also plays an important role in the cycling position, as well as, in the aspect of comfort.

Starting with the E32, its cycling position has a few problems. The handlebar is positioned quite high, but its relation to the saddle position is very small, with only 10 centimeters of difference when the saddle is positioned in its highest position. This, combined with the cranks, which are positioned almost vertically under the saddle, may result in a position that is a quite leaned forward. In addition, the fact that the cranks are positioned right under the saddle will result in a quite high cycling position when the saddle is positioned high enough in order to have an adequate legs extension for pedaling. In addition, the fact that this vehicle's saddle height adjustment possibilities are restricted to only 3 options will create problems in finding the suitable saddle height for a certain person.

The problem of having the cranks placed right under the saddle is also a problem present in the Trike, in the Senator, and to some extent in the Carro. This will result in high cycling position as it

was mentioned before. From these vehicles the Carro is the one that has the cranks positioned a little more forward, thus, resulting a not so high position when compared to the Senator, the Trike, or the E32.

One other problem encountered in some of the chosen vehicles, which immediately jeopardize their cycling position is the handlebars placed to low in relation to the saddle. This problem is not very accentuated in any of the vehicles, as none of the chosen vehicles has an handlebars positioned lower than the saddle, however in some of the vehicles the handlebars height is very close to the saddle height. Thus, resulting in a not so upright position, but instead in a rather lean-forward cycling position. The vehicles that have these characteristics more eminent are the E32 and the Trike.

Regarding the position of the cranks in relation to the saddle, three of vehicles have their cranks markedly positioned forward in relation to the saddle. They are the PAV3, the Revive DX, and the EZ Roll Regal. This feature combined with a handlebar high enough, which is the case in these three vehicles, result in an upright cycling position. Moreover, the type of saddle also plays its roll in promoting a comfortable and ergonomic cycling position. If the saddle has a backrest this will contribute to a more upright or even a bit reclined position, depending on the angle of the backrest. These 3 vehicles all have saddles with backrest; in addition, this feature is also present in the Top End Excelerator.

Other important aspect contributing for a good cycling position is the possibilities that a vehicle have of modifying the position of the three crucial parts contributing to the cycling position, the saddle, handlebars, and cranks. Usually the vehicles do not offer a possibility of adjusting the cranks position, but only the saddle, and the handlebars. With the particularity that the handlebars are very often only adjustable forward or backward, not being possible to adjust their height. All of the chosen vehicles offer the possibility of changing the saddle position, however, in some of them these possibilities are more limited than in others. The vehicle with the most limited saddle adjustment possibilities is the E32, and the one with the most possibilities is the Revive DX. Regarding the cranks position, actually only one vehicle offers this particular adjustment possibility, the EZ Roll Regal, with its possibility of adjusting the frame size, thus, contributing for the adjustment of the crank position at the same time. When it comes to handlebars adjustment possibilities, all of the chosen vehicles offer the possibility of changing the position of the handlebars. However, the one

that stands out for its multi-possibilities of adjustment is, by far, the Revive DX, offering the possibility of adjusting the handlebars forward and backwards, as well as, up and down.

In conclusion, the Revive DX seems to be the vehicle offering the best cycling position, offering not only an upright and a bit reclined position, but also multiple-adjustment possibilities, which gives the cyclist the possibility of better finding the right fit.

6.1.2. C) Portability

Especially in urban areas, the bicycles are usually stored indoors, and for this reason often need to be carried on stairs, through doorways or even on lifts. This is mainly due to the risks of theft and vandalism, as well as the bicycles susceptibility to corrosion factors, like rain and wind. Other common activities, which require a bicycle to be portable, include putting it on the car, taking it in a public transport like a train, or even just take it up some stairs just because there is no other way of reaching the place one wants to go to. If some of these tasks already may seem to be challenging for a younger person, they can be a real burden for elderly people.

The most important aspects contributing to bicycle's portability are its weight and size. The older a person is, the heavier things seem to become. With many bicycles weighing 15 to 20 kilos, the simple task of carrying it up a few stairs may be really challenging and energy consuming. The size of the bicycle also has a great impact in a few common activities like store indoors, go through doorways, or take it in the train. Some bicycles, especially tricycles and quadricycles are often very wide/large, which may make some of these activities very difficult or even impossible.

As far as weight, a cycling vehicle for seniors should not weigh more than 10 kilos (Spolander, 2007). The use of lighter materials like aluminum or titanium, as well as special techniques like multiple butted tubing or heat treatment can make this possible. However, the price of the vehicles for seniors should be kept accessible, therefore preference should be given to cheaper materials over more expensive ones, like titanium and carbon fiber.

Concerning size, the most important aspect is that the vehicle should not be wider than a normal doorway (around 80 cm). For this, the vehicle should be designed taking this measure into account. Another possibility is also to make the vehicle foldable, giving the possibility to the user to diminish its size when needed. This raises one question. Can a cycle be at the same time good to cycle, easy to fold, resistant, and light in weight? The answer to this question is probably yes, however, this somehow complicated combination might raise another problem, the increase in the price of the vehicle.

Comparative analysis

Starting with the weight, all the vehicles are very heavy in relation to what could be the ideal weight of a bicycle for elderly persons (less than 10 kilos). The heaviest vehicle is the EZ Roll Regal with 29,5 kilos, and the lightest is the Senator with 18 kilos. This shows clearly that very heavy materials are being used in the construction of all the vehicles. In addition, although the weight of the PAV3 is not available, it is quite sure that this vehicle weighs over 20 kilos like almost all the other vehicles.

Regarding the aspect of size, the most important measure is the width of the vehicle, as it determines if a vehicle can be easily be taken indoors. So taking into account that the a standard measure of a doorway is 80 centimeters, it is easy to realize that all the vehicles seem to have taken this measure into account, as the width of all the vehicles measure less than this, maybe with the exception of the PAV3 that its width measures exactly 80. Although the width measures of the Revive DX and the Senator are not available, their measures are for sure less than 80 cm due to the fact that they are bicycles and not tricycles, like all the other vehicles. Moreover, the Top End Excelerator is the only tricycle that its width is not available and therefore the only one impossible to know whether it fits or not through a normal doorway.

Still taking the aspect of size into consideration, it is important to make reference to two vehicles, the E32 and the Trike. The E32, for being the only foldable vehicle from the chosen vehicles, a characteristic that allows its user to easily store it or carry it on a train for example. And the Trike for the its front wheels folding feature, allowing the vehicle to become narrower when needed to be

carried through doorways or stored. In conclusion, it seems that the E32, although not being the lightest vehicle, is probably the one that is most portable, due to the fact that of being foldable.

6.1.2. D) Price

The price of a product is an aspect that has a great deal of importance for buyers in general, however, for the elderly persons this aspect represents a much heavier burden, due to their usually lower incomes. It is a fact that the elderly populations are usually at most risk of being poor in comparison to the working-age populations. In fact, one-in-six of all 74 million elderly living in the EU are at risk of poverty, accounting a total of about 13 million persons (Zaid, 2006). Regarding Portugal, where the value of retirement pensions is one of the lowest in EU (CNIS, 2008) and where 29% of those aged 65 and over live below the limit of poverty (INE, 2007), the price definitely plays an important part when it comes to deciding whether to buy or not a certain good. Furthermore, in some countries like Sweden for example, the elderly population is in fact a group with a strong purchasing power (Spolander, 2007), but this can by no means be generalized. All in all, in 14 out of all 25 EU member countries, the elderly populations are more often at risk of being poor when comparing to the working-age populations (Zaid, 2006).

The price of a bicycle is very much dependent on the material of which it is made of. Materials usually used in the construction of bicycles can range from high-tensile steel, one of the cheapest materials used, find in lower priced bicycles, through aluminum or chromoly steel, very widely used materials, medium priced, till very expensive materials like titanium or carbon fiber, find in high-priced bicycles.

Comparative analysis

The prices of the chosen vehicles are all quite high if to be inserted in the Portuguese market. With the exception of the EZ Roll Regal, which costs 315 euros, all the other vehicles cost more than one month of the national minimum salary (450 euros). The two vehicles with the lowest prices are the EZ Roll Regal (315 euros) and the PAV3 (675 euros). The most expensive vehicle is the Carro,

costing 1802 euros. Overall, except for the EZ Roll Regal, all the other vehicles are quite highly priced if they were supposed to be commercialized in the Portuguese senior market.

6.2. Survey on the Portuguese Potential Users of Senior Bicycles

6.2.1. Background

Nowadays, it is commonly assumed that everything produced should be accessible to all the potential users. However, this general principle should be substantiated with the demonstration that this is possible and it is economically viable.

According to the "design for all" or "universal design" principle approach, the needs, capabilities and preferences, of all the potential users should be taken into account during the design and development of new products (Emiliani, 1998). In today's context, with complex systems, it is often impossible to support the idea of a single system that is good for all potential users. As the risk is that one will produce products that are actually not good enough for anyone. There are problems, which can be very difficult to solve, through better design of equipment, services and applications of general use, or simply because the costs to do so are too high. In these cases, assistive technology, definable as special technology applications on behalf of people with disabilities or older people, can play an important role on addressing a wide number of impairments like mobility, hearing and cognitive impairments.

According to Emiliani (1998), four levels of activity can be identified, they are: replacing or enhancing impaired functions, adapting the environments, supporting people directly in the different environments, supporting carers to reduce costs involved in daily tasks of caring. Within this categorization system, the present project fits within the first level of activity, as it is a research done in the area of personal devices for mobility and transportation (Emiliani, 1998).

6.2.2. Sample

6.2.2. A) Characteristics of the group of the non-cyclists

The average age of those interviewed from the group of people who do not cycle was approximately 73 years, the youngest person inquired was 65 years old and the oldest was 83. The group, as it was mentioned before, consisted of 10 women and 10 men.

6.2.2. B) Characteristics of the group of the cyclist

The average age in this group was approximately 70 years, the youngest person had 65 years old and the oldest person had 85 years old. The group consisted of 18 men and 2 women.

6.2.3. Age at which the seniors stopped cycling and the motives for it

6.2.3. A) Group of the non-cyclists:

From the 20 inquires in this group, 9 never rode a bicycle in their life. The one's who did rode stopped in average at the age of 30 years, the earliest age at which someone stopped cycling was at 14 years of age, and the latest age at which someone stopped cycling was at the age of 50 years. As far as motives for stop riding, most people stopped riding due to buying another vehicle for transportation, most often a car. Only one person stopped due to health motives.

6.2.4. How often the seniors cycle

6.2.4. A) Group of the cyclists:

A great part of the senior cyclists inquired, more precisely 9 out of 20, cycle everyday but the rest of them do not cycle so often, in fact 8 of the subjects cycle only once a week or less. In addition, the two women in the group cycle everyday.

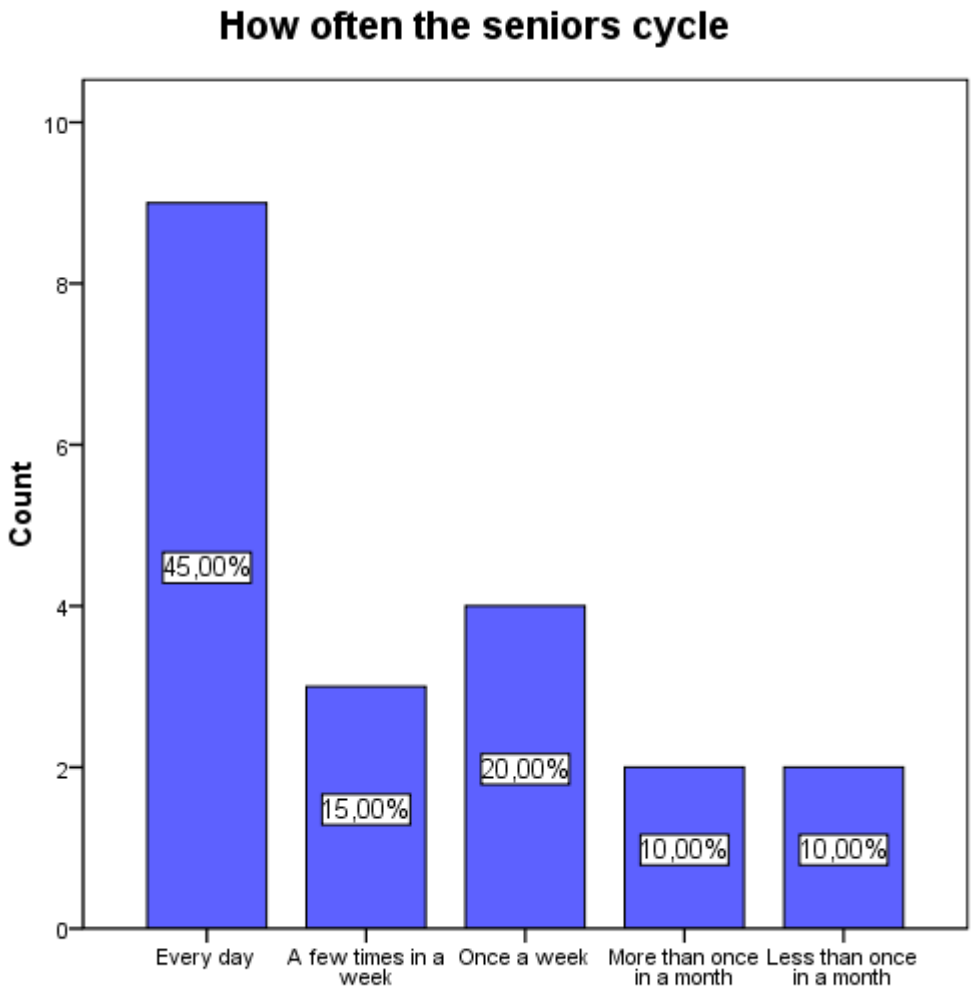


Figure 10.

6.2.5. Motives for cycling

6.2.5. A) Group of the cyclists:

Most people inquired cycles due to two motives, one is for exercising and the other is for the pleasure of cycling. Each of this motives acquainted 35% (n=7) of the rates each, making a total of 70% or14 persons out of 20. However, other than these motives, there was only one other motive rated, this motive was “cycling as way of transportation”, acquainting the remaining 30% (n=6). This means that all the three motives had almost the same weight.

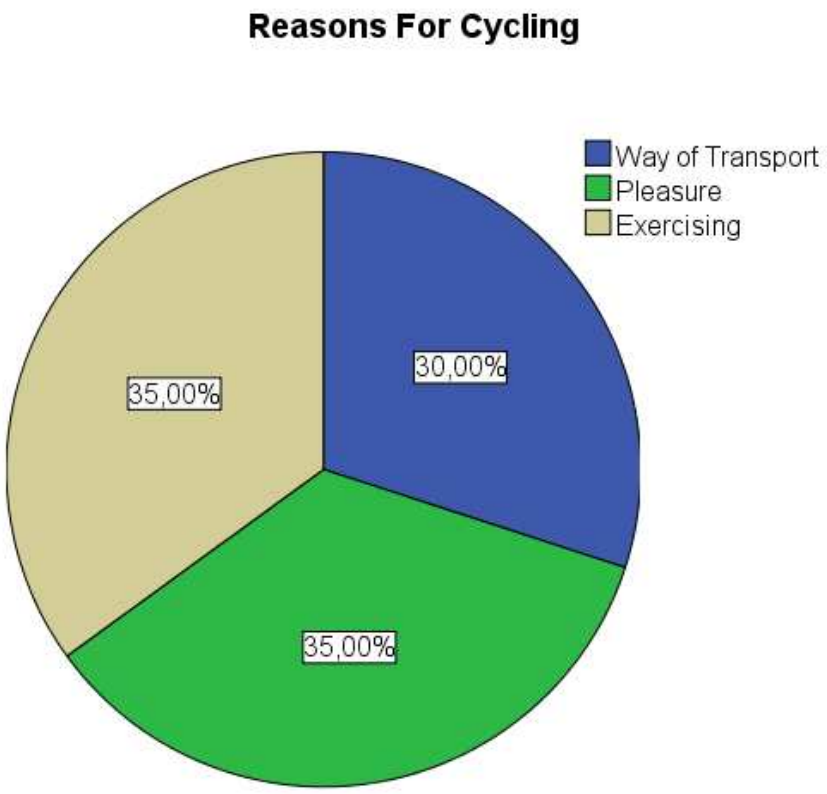


Figure 11.

6.2.6. Acquaintance with the existence of senior bicycles

6.2.6. A) Group of the non-cyclists:

From the 20 persons inquired in this group, 12 persons were acquainted with the existence of senior bicycles, while 8 persons had no idea about its existence.

6.2.6. B) Group of the cyclists:

Within this group, the scenario was quite similar, with no major difference between the number of those who are acquainted with the existence of senior bikes and those who are not. Maybe on

contrary of what would be expected from this group, a total of 9 persons out of 20 where acquainted with the existence of senior bicycles, while 11 persons did not know about the existence of senior bicycles.

6.2.6. C) Total sample:

Overall, the results are quite straight forward, indicating that approximately 50% (52,5%, n=21) of the sample knew about the existence of senior bicycles and approximately 50% (47,5%, n=19) of the persons did not know about it. In terms of correlation with the variable gender, the percentage of women who were acquainted with the existence of senior bicycles was larger than that of men, with 67%(n=8) of all women against 46% (n=13) of the men.

		Knows about the existence of senior bicycles		
		Yes	No	Total
Gender	Male	13 (46%)	15 (54%)	28
	Female	8 (67%)	4 (33%)	12
Total		21 (52,5%)	19 (47,5%)	40

Table 18.

6.2.7. Considering to start cycling (again)

6.2.7. A) Group of the non-cyclists:

A total of 12 persons out of 20 would consider start cycling again in case they had access to a bicycle that would fulfil their needs as cyclists. The variable gender did not have an important role in these results, in fact, the group of those who would consider start cycling again and the group of those who would not consider start cycling again have within each other the exact same number of men and women.

Would consider starting to cycle if had access to a suitable bicycle

		Yes	No	Total
Gender	Male	6	4	10
	Female	6	4	10
Total		12 (60%)	8 (40%)	20

Table 19.

6.2.8. Ever thought of buying or would consider buying a senior bicycle

6.2.8. A) Group of the cyclists:

The results showed that 7 out of the 20 inquired persons have thought about or would consider buying a senior bicycle. Although the number of women in this group is very small (only two), it is important to mention that only male participants ever thought about or would consider buying a senior bicycle.

6.2.8. B) Group of the non-cyclists:

In this group the results were very similar, with 6 out of 20 of the inquired persons who responded, they have thought about or would consider buying a senior bicycle. The only difference was the fact that those 6 persons where not only men but there was also 2 women among them.

6.2.9. Reasons why seniors would not be interested in buying a senior bicycle

6.2.9. A) Group of the cyclists:

Out of the 13 persons who would not be interested in buying a senior bicycle 9 answered they would not be interested because they simply do not need it yet. One person had fear of falling and because of this would not want to buy any bicycle, and the remaining 3 persons just would not be interested because they do not know what is a senior bicycle.

6.2.9. B) Group of the non-cyclists:

Within this group, 14 persons answered they would not be interested in buying a senior bicycle. Five of these persons would not be interested because they would not even consider starting to cycle now due to the fact that they never did it before. Three persons had fear of falling while cycling; other 3 persons did not consider a bicycle necessary because they own a car, and the remaining 3 were not interested because they did not know what is a senior bicycle.

6.2.9. C) Total sample:

From all the persons inquired, who were not interested in buying a senior bicycle, their reasons by order of importance were: I do not need a senior bicycle (yet), I do not know what is a senior bicycle, I never cycled I will not start now, and I have a car I do not need a bicycle.

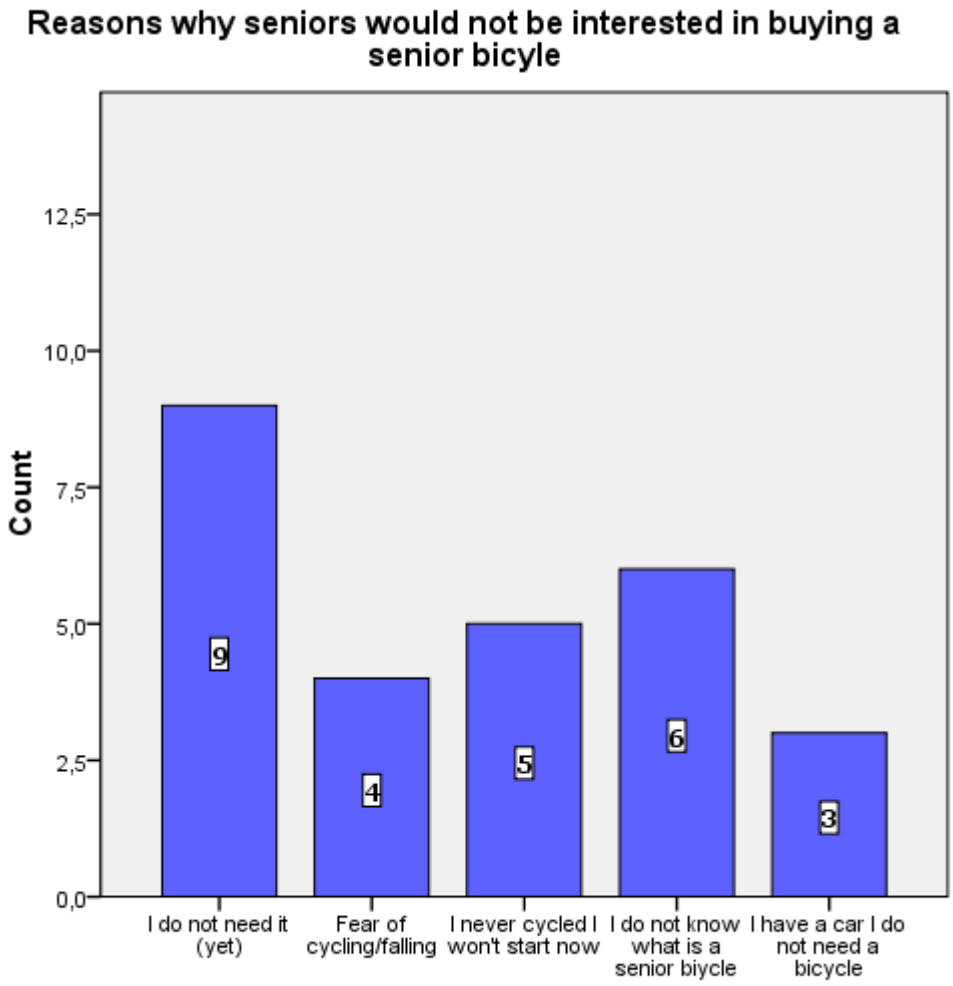


Figure 12.

6.2.10. How much would the seniors be willing to pay for a senior bicycle?

6.2.10. A) Total sample:

Out of the 13 persons who would be interested in buying a senior bicycle, 7 of them would be willing to spend between 300 and 500 euros, 3 of them would be willing to spend between 500 and 700 euros, and the remaining 3 would be willing to spend between 200 and 300 euros. In addition, although this sample is small and unrepresentative, it is noticeable the fact that when comparing

men and women, the two women would not be willing to spend as much money on a senior bicycle as the men.

How much would the seniors be willing to pay for a senior bicycle

		* 200-300	* 300-500	* 500-700	Not applicable	Total
Gender	Male	1	7	3	17	28
	Female	2	0	0	10	12
Total		3	7	3	27	40

* Values in euros

Table 20.

6.2.11. Important aspects in a senior bicycle

6.2.11. A) Total sample:

In order to obtain the opinion from all respondents on which aspects they consider most important in a senior bicycle, the respondents were asked to rate the degree of importance that they attribute to the following four aspects, safety, comfort, way the vehicle looks, and price. In first place the results from both interviews where analysed together, and only after that the results from each group were analysed separately, in order to check if there were any divergences between the opinions of the two groups.

Safety was rated the overall most important aspect in a senior bicycle, with a total of 19 persons (47,5%) rating it as *very important* and 17 persons (42,5%) rating it as *important*. All together 36 persons or 90% rated it as very important or important. In addition, safety was never rated as *not important*.

Comfort was the next aspect which got most rates as *very important*, with a total of 13 person (32,5%) rating it as very important. However, the opinions on this aspect were not so uniform as in the safety aspect. But on contrary, one third of all inquires rated it as *very important*, another one third rated it as *important*, and another one third rated it as *not so important*. It also did not receive any rates as *not important*.

The results showed that price was the third most important aspect in a senior bicycle. Price was rated as *very important* by 20% of the respondents and as *important* by 25% percent. But also 40% of the respondents considered it *not so import*, and 15% even rated it as *not important.* Indicating a clear 50/50 situation between those who consider the aspect price important and those who consider it not so relevant.

The way the bicycle looks was the least important aspect in the respondents' opinion. This aspect was rated as *not important* by 34 persons or 85% and the highest it was rated was as *not so important,* by only 6 persons. Thus, showing its irrelevance in the respondents' opinion.

In resume, according to the respondents' opinions one could arrange the four aspects in the following order of importance, first and most important aspect would be safety, second would be comfort, third would be price and last and forth would be the way the bicycle looks.

Moreover, it was not found any significant correlation between the gender of the participants and the way they rated the different aspects, except for the correlation between gender and the comfort aspect. Where in this case, the aspect comfort was rated as *very important* by 50% (n=6) of the female respondents, against only 25% (n=7) of the male inquires, which also rated comfort as *very important*. Therefore, there could be a tendency to believe that women attribute greater value to the aspect of comfort than men.

Gender * Comfort aspect

		Very important	Important	Not so important	Total
Gender	Male	7 / 25%	10 / 36%	11 / 39%	28
	Female	6 / 50%	3 / 25%	3 / 25%	12
Total		13	13	14	40

Table 21.

6.2.11. B) Comparing the group of the cyclists with the group of the non-cyclists:

The results from both groups, considering the way each of the groups rated the importance of some aspects in a senior bicycle, were very similar, with very few differences. The only major difference between the two groups was the fact that the majority of people in the group of the non-cyclists rated the aspect of comfort as *very important*, while the majority of people in the group of the cyclists rated it "only" as *not so important*.

Statistics/Group of the non-cyclists

		Safety	Comfort	Way the vehicle looks	Price
N	Valid	20	20	20	20
	Missing	0	0	0	0
Mode		1	**1**	4	3

Table 22.

Statistics/Group of the cyclists

		Safety	Comfort	Way the vehicle looks	Price
N	Valid	20	20	20	20
	Missing	0	0	0	0
Mode		1	**3**	4	3

Table 23.

6.2.12. Cycling accidents

6.2.12. A) Group of the cyclists:

From the 20 elderly cyclists inquired, 5 of the subjects had at some point been involved in a cycling accident, but all of the 5 subjects rated the incident they had been involved in as *not serious*.

6.2.13. Observations

The most unexpected finding during the data collecting process was that one of the inquired persons, after answering to the last question of the interview (about if they have ever had an accident while cycling), started to explain about one modification he had done to is bicycle due to one accident he had. The modification consisted of cutting the top tube of the frame and welding it back in a lower position, making it look like “lady’s frame”. He explained he made this modification himself after having two accidents while trying to dismount his bicycle. This way, with a lower top tube, he could mount and dismount the vehicle easier. An interesting thing was that the author himself had noticed the fact that quite many male cyclists who were inquired cycled with a “lady’s frame”, which is not so common. This is an example of learning from the difficulties encountered, but it shows that those who bicycle regularly sooner or later will realize that the mounting and

dismounting of the vehicle is one of the most challenging and dangerous things for an elderly cyclist, and that something should be done within the bicycle industry field.

6.3. Review and Evaluation of Existing Health Promoting Programs Using the Bicycle as an Instrument

6.3.1. The Programs

From the Internet search conducted 4 programs were found. These 4 programs were "Over 50s Riding Program", "Older Adult Three-wheeled Bicycle Program", "Wheelchair biking program", and a program within the "Algarve's Adapted Sports Regional Program" (Programa Regional de Desporto Adaptado do Algarve).

6.3.1. A) Over 50s Riding Program[1]

The Over 50s Riding Program" is an Australian program designed to encourage the residents of Victoria with an age over 50 years to get active, and help them maintain their mobility, independence and improve their quality of life. Bicycle Victoria, the largest cycling organisation in Australia, is implementing the program in conjunction with the Council on the Ageing (COTA). This program recognises that cycling is a popular and appropriate form of physical activity for seniors with a strong evidence base (Bicycle Victoria, 2008).

The aim of the program is to develop a network of community cycling groups for people over the age of 50 years, led by trained voluntary, local "Ride Leaders". These "Ride Leaders" receive basic training from Bicycle Victoria. The "Ride Leaders" role is to "set up local riding groups and provide advice on routes, paths and café stops, set participants up with buddies and be a local point of contact and support" (Bicycle Victoria, 2008). The "Ride Leaders also offer advice on riding technique and bicycle maintenance, and provide the necessary motivation. The program wishes to involve cyclists from culturally diverse backgrounds and living in low socio-economic areas; recruit

[1] Bicycle Victoria, 2008

both “Ride Leaders” and where necessary “Ride Leader Buddies”, develop local capacity by partnering with retail, sporting and seniors organisations; develop web based resources such as maps to support the riders; and increase understanding of the health and social benefits of cycling for older people.

As the program seeks to involve a wide range of persons, rides of different levels are offered, targeting from beginners through those more experienced. The frequency of the rides varies from group to group, according to the needs of the participants, and the level of difficulty appropriate for the cycling experience of the participants. In order to participate in the program all it is needed is a bicycle and a helmet. A helmet is mandatory not only due to safety but also because it is illegal to cycle without one in Australia. In addition, a local bicycle shop provides assistance if needed to those with bicycles which have been stopped for a while (Bicycle Victoria, 2008).

6.3.1. B) Older Adult Three-wheeled Bicycle Program[2]

The Portland Transportation Office implemented the ”Older Adult Three-Wheeled Bicycle Program” in Portland, US in 2006. The program aimed at having seniors aged 60 and over cycling again. The Portland Transportation Office recognises not only the health benefits of cycling but also the joy that the seniors can obtain from it (Maus, 2006).

With the objective of making cycling safer and more accessible to the seniors of Portland, the Portland Transportation Office purchased a fleet of tricycles, and offered two free sessions per week at Willamette Park in Southwest Portland. These sessions work as classes, where support is offered to the seniors who are beginning to cycle again. The interested persons do not need to own a vehicle to take part in the class rides, as the tricycles and bicycle helmets for the classes are offered free of charge. The seniors just need to book a class, and they can go and try out the tricycles, and have their questions and concerns about cycling answered (Maus, 2006).

[2] Maus, 2006

According to Program Coordinator Kirsty Hall, the program was a success. From the Program Coordinator's point of view, the most rewarding part of the program was to see how inspiring cycling is for the seniors, and to witness the excitement and fun they have doing it.

In order to obtain feedback on the program development, the Portland Office of Transportation partnered with a researcher from the Oregon Health and Science University, who was looking into how seniors might retain function as they age, and how cycling could play a part in that. This feedback was afterwards used to develop a senior section of their Portland Bicycle Master Plan. The mission of the Portland Bicycle Master Plan is to make bicycling an integral part of daily life in Portland.

Other partners supporting the "Older Adult Three-Wheeled Bicycle Program" are The Bicycle Transportation Alliance (BTA), a non-profit membership organization working to promote bicycling and improve bicycling conditions in Oregon and south-west Washington, Elders in Action, an non-profit organization that seeks to assure the active involvement of the seniors in the society, and the Portland Parks and Recreation Department (Maus, 2006).

6.3.1. C) Wheelchair Biking Program[3][4][5]

The wheelchair biking for the treatment of depression is the title of a specific recreation therapy program, wheelchair biking, for the treatment of depression in elderly persons. This program utilizes a Duet bike, which is a modified tandem bicycle manufactured in Germany by Robert Hoening. This tandem bicycle has a special design where the front of the system is a detachable wheelchair that function as the front wheel of the bicycle. This system enables the subjects, at all functioning levels, even with severe disabilities, to ride in the wheelchair while the caregiver or family member pedals and steers in the back (Fitzsimmons et al, 2002).

The main aim of this program is to "reduce depressive mood in older adults and to provide a complementary or alternative treatment to medications" (Fitzsimmons et al, p.1, 2002). Its target

[3] Fitzsimmons et al, 2002
[4] Fitzsimmons et al, 2003
[5] Fitzsimmons & Buettner, 2002

population are older adults in long-term care facilities, who are depressed or at risk for depression. Fitzsimmons et al (2003) released a guideline about the implementation of this program. According to the authors of this program, the program involves groups of three to five participants scheduled for each session. The participants receive the therapeutic biking program for one hour a day, five times a week, for a total time of two weeks. This one-hour program is divided in two parts, a riding part and a group discussion part. The riding part consists of a 15-minute ride around the facility, and the group discussion part takes place while the other participants are waiting for their turn to ride. During the group discussion part the staff personnel seats with the participants and talks about past life bicycle-riding experiences.

This program was already implemented in a long-term facility in Upstate New York using the same guidelines established by Fitzsimmons et al (2003). This 2 weeks program had the name of Easy Rider Program and was implemented as a trial by the two of the authors of the guidelines, Fitzsimmons and Buettner. As far as results, the Easy Rider program had a very positive effect on depression levels. The mean Geriatric Depression Scale (GDS) scores for the participants dropped 3.47 points. And besides one of the participants, whose score remained the same, all the depression scores improved. The main conclusion of the study was that a therapeutic biking program provides a refreshing, safe new tool to use in the battle against depression as it improves the social, emotional and physical well-being of the elderly persons with depression (Fitzsimmons & Buettner, 2002).

6.3.1. D) Algarve's Adapted Sports Regional Program[6]

The Algarve's Adapted Sports Regional Program is a Portuguese program that is being implemented in the city of Faro. The program has the aim of offering handicapped people and people with diminished mobility a possibility of moving around the city with a comfortable and easy to use transport. For this, the Faro's Civil Government disposed six adapted bicycles for the transportation of handicapped persons and persons with diminished mobility (Manuel, 2008).

The six bicycles will be available free of charge, resulting from a partnership between Faro's Civil Government and "Grupo Sportis". From these six bicycles, two of them are tandem, and two others

[6] Manuel, 2008

are handcycles. The local Firemen Department will be responsible for the bicycles, thus persons interested to use the bicycles should contact the Department (Manuel, 2008).

This program acknowledged the fact that there are over 3000 handicapped persons in the Algarve province, and that by offering special bicycles for this group, their quality of life would improve. Moreover, as Faro is a city that is very much visited by tourists, this program was planned also with the idea of offering the tourists with diminished mobility a possibility of visiting the city using the special bicycles (Manuel, 2008).

Program	Concrete aim	Type of bicycles used	Equipment required from the participants	Location	Target group
Over 50's riding program	-Activate the participants -Help them maintaining mobility and independence -Create awareness of the benefits of cycling for the elderly	-Own bicycle	-Bicycle -Helmet	Victoria, Australia	Residents of Victoria aged 50 and over
Older Adult Three-wheeled Bicycle Program	-Making cycling safer and more accessible for the elderly -Activate the seniors	-Senior bicycles	-No equipment needed	Portland, United States of America	Seniors aged 60 and over
Wheelchair Biking Program	-Reduce depressive mood in older adults -Provide a complementary or alternative treatment to medications	- Duet bike, a modified tandem bicycle with a detachable wheelchair that function as the front wheel of the bike	-No equipment needed	Upstate New York, United States of America	-Older adults in long-term care facilities who are depressed or at risk for depression
Algarve's Adapted Sports Regional Program	Offering handicapped people and people with diminished mobility an easy and comfortable transport to move around the city	-Tandem bicycles -Handcycles -Adapted bicycles	-No equipment needed	Faro, Portugal	-Handicapped people -People with diminished mobility

Table 24.

6.4. Planning of the Smartbike Future Prototype Test

In order to obtain credible information from the study group involved in the testing process of the Smartbike prototype, it is crucial to have their direct involvement with the vehicle. Therefore a skills circuit recreating realistic situations encountered in the cycling environment should be build for the Smartbike prototype test. This skills course will account seven different skills obstacles based on the White's *Bicycle Skills Course Instruction Manual* (1999). This skills circuit will give the study group a possibility to experience the Smartbike and after that, based on their own experience, better express their opinions about the vehicle. Each member of the study group will be individually interviewed. In this interview each member of the study group will have an opportunity to express his opinion about the Smartbike prototype based on his own experience with the vehicle.

The performance of the study group will also be taken into consideration. As the performance of each individual will not entirely be dependent on the vehicle, but more on the individuals' own skills, the evaluation of the study group's performance will focus more on the vehicle than on the user. It will look at how the vehicle manages through the course, how the vehicle seems to fit the individuals, and which features in the vehicle seem to be problematic. In order to make this task easier, the study group performance in the circuit will be filmed. With this, the author will be able to instruct each member of the study group through the course, and afterwards carefully watch the footage of their performance to understand how the vehicle responded to the test.

6.4.1. Planning of the circuit

The skills circuit planned for the prototype test is based on the Bicycle Skills Course Instruction Manual planned by James White, a Secretary of State in the United States (1999). White planned a skills course, consisting of seven different obstacles, and recommended its implementation in school playgrounds and other places where children are present. The aim of this skills course is to measure children's actual riding ability before entering street traffic. This skills course offers children a possibility to practice skills such as balance and handling of the bicycle in a safe environment. Although this course was planned with a different purpose than that of the present study, it offers a good example of a course, which recreates realistic situations able to measure the riding ability

necessary to be able to cycle in the street traffic. Therefore, the use of the vehicle by the study subjects through this course will acquaint them with the necessary experience for expressing their opinion about the Smartbike prototype.

A few changes had to be made to the original skills course planned by White. These changes included:

a) The wideness of the cycling lanes, which were increased from 1 meter to 1,5 meters. This change had to be made due to the fact that the original course was planned for bicycles and the present course was planned for a tricycle prototype with a wideness of 50 centimetres.

b) In the straight-line control obstacle the wideness of the cycling lane was also increased from 15-20 centimetres to 55 centimetres due to the Smartbike wideness of 50 centimetres.

c) One obstacle was added to the course, the uphill obstacle, due to the need of testing the gearing system suitability for elderly people.

d) One obstacle was left out, *the slow speed control*, due its unsuitability to the present study. Slow speed control does not make sense to test when cycling with a tricycle because it does not really require balance control.

6.4.2. Usability Test (with the study subjects)

In this point the circuit is presented, along with the instructions to conduct the test through each of the obstacles, and also the purpose of each obstacle is explained.

6.4.2. A) Mounting and dismounting the vehicle

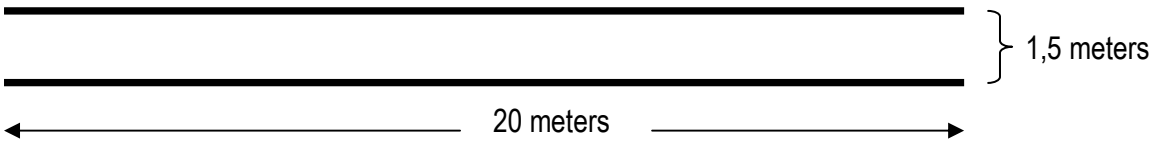


Figure 13.

Explanation: The user must mount, steer the vehicle without loosing balance or swerving out of the lanes and dismount the vehicle.

Purpose: To check how the study subjects mount, start, and dismount the vehicle while maintaining control and balance.

6.4.2. B) Circling and changing direction

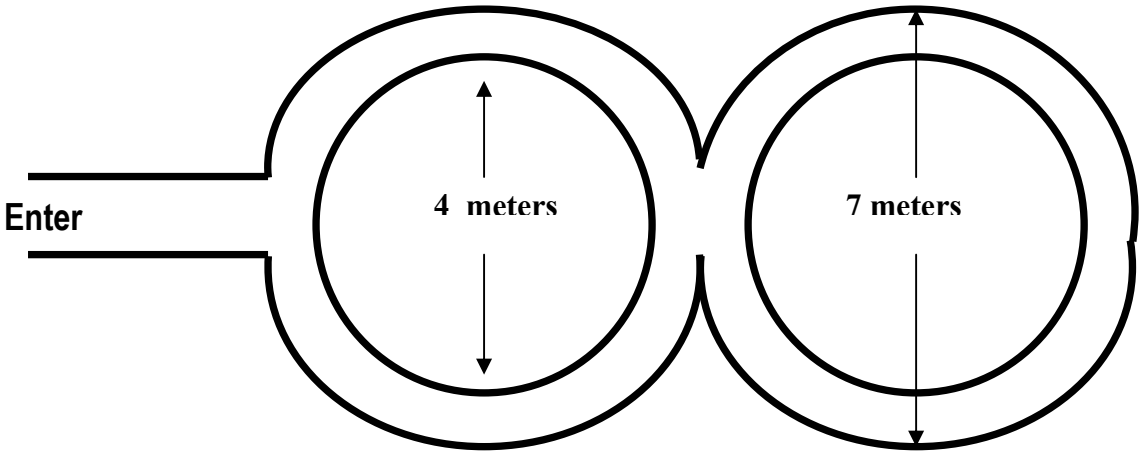


Figure 14.

Explanation: The user should start to the right and maneuver through the circles in a figure eight.

Purpose: Check the subjects' steering control and posture while changing directions.

6.4.2. C) Straight-line control

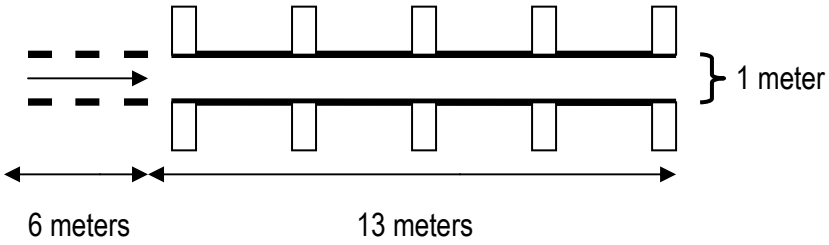


Figure 15.

Explanation: The user should steer between all the markers without touching them or stopping.

Purpose: To test control and steering coordination.

6.4.2. D) Weaving and maneuvering

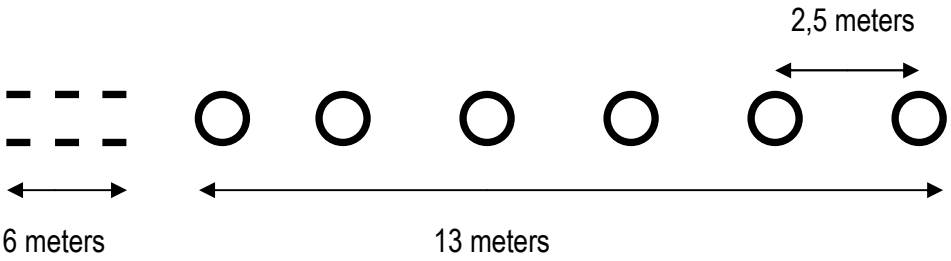


Figure 16.

Explanation: The subjects should weave alternately to the right and left without hitting any obstacle.

Purpose: To test subjects' steering control and posture, and vehicle stability.

6.4.2. E) Stopping test

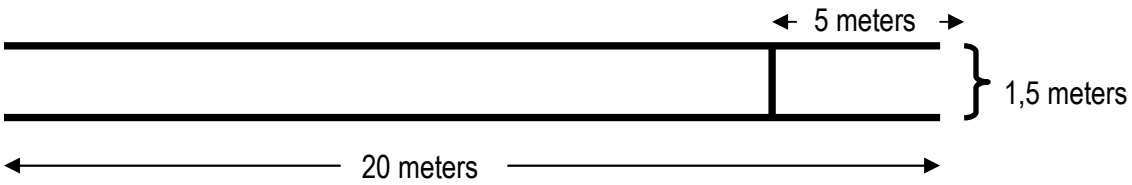


Figure 17.

Explanation: The user should ride through the first 15 meters of the lane and be able to bring the vehicle to a complete stop within the last 5 meters.

Purpose: To test braking ability, control, the braking system suitability, and vehicle stability during the braking.

6.4.2. F) Short radius turning

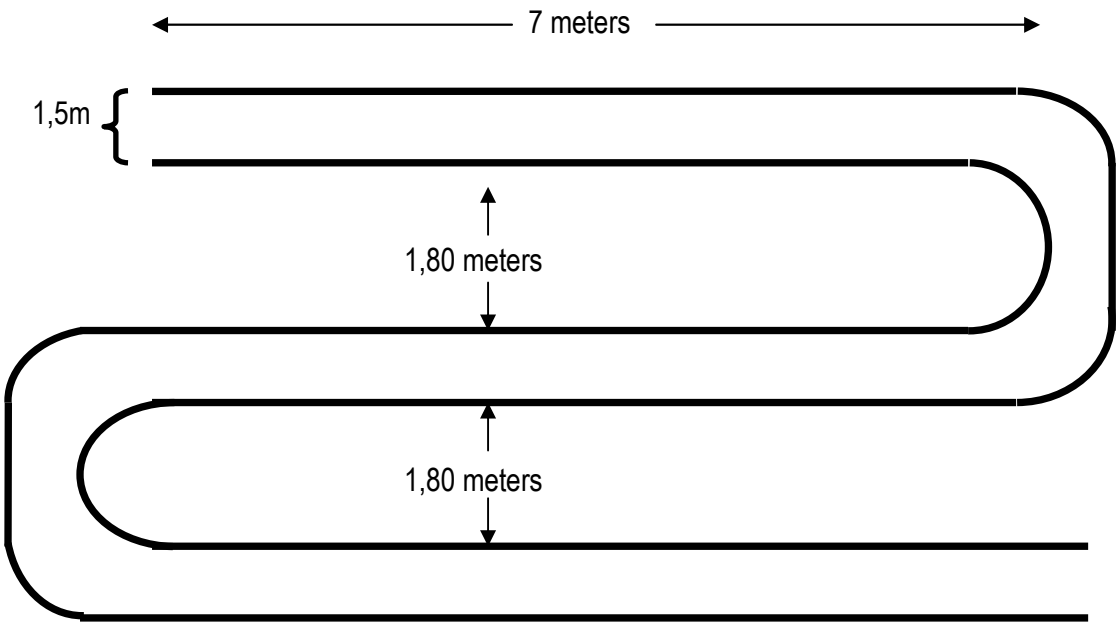


Figure 18.

Explanation: The user should maneuver through the course without veering over the lanes.

Purpose: To test speed control, steering coordination and vehicle stability. Also, understand how the user feels in the vehicle when doing tight turns.

6.4.2. G) Uphill test

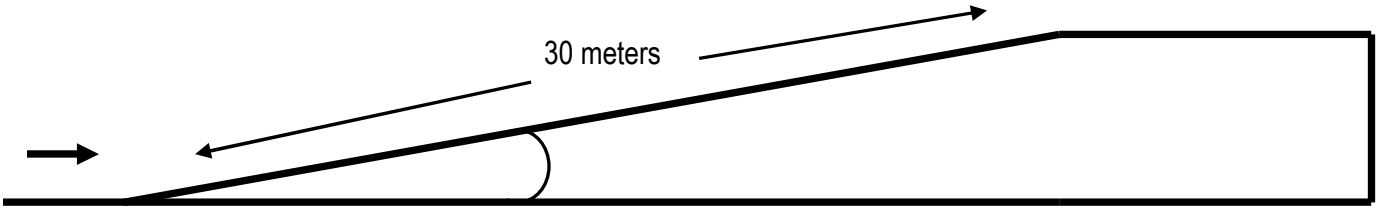


Figure 19.

Explanation: The user should cycle the 30 meters uphill until the top.

Purpose: To test how the gearing system helps the elderly user pedaling uphill. And understand if the Smartbike gearing system is suitable for the elderly user.

Instruments to evaluate the Usability Test

a. Interview with the subjects (Appendix 2)
b. Observation form (Appendix 3)

6.4.3. Technical Test (without the participants)

Before the test with the study group, the Smartbike prototype has to first pass two evaluations to ensure it is acquainted with all the necessary safety requirements in order to be used by the study group, and by any person in general. First the author himself will use the vehicle for one week, and after that it will have to pass the technical test, and only then it will be prepared to be used by the study group. The technical test planned is based on the wheelchair test methods from the International Standards Organization (ISO) (Cooper and Cooper, 2004). This technical test, as the

test from ISO, is divided in two main parts: stability and strength. In addition, for this study a third part was added, the braking test.

6.4.3. A) Stability test. Forward / Backward / Lateral

The stability test is divided in three subtests, forward, backward and lateral stability tests. All these tests were performed on a ramp that could be slowly elevated. The idea is to slowly elevate the ramp until the uphill wheels begin to lift off the platform. These tests will give an idea of how easily the vehicle would tip, by other words how stable or dangerous the vehicle is. The stability of the Smartbike will be tested with its adjustments in their minimum and maximum positions since they can also influence the stability of the vehicle. In addition, it is important to remember that these tests usually are performed using a dummy or a real person. For the Smartbike test the author will use a friend of him to help him in the process. In the stability test not only will be taken into consideration the "inclination angle" when the wheels begin to lift off the platform, but more important, the least stable position where the user feels safe and comfortable when performing common driving activities like ascending ramps or descending ramps.

6.4.3. B) Strength tests. Static strength / Impact strength / Fatigue strength

According to ISO (Cooper and Cooper, 2004) the strength standards are divided into three categories: static strength, impact strength and fatigue strength. These three categories result on three different strength tests. As some of these tests require special machines not easy to have access to, a few modifications will be made to the original ISO strength tests but always with the intention of recreating the original ISO test the best possible way. These modifications are here carefully described in order to avoid confusions.

The static strength is used to determine the adequacy of the vehicle components. In the original ISO static strength test, machines are used to slowly apply force to different components of the wheelchair, like armrests, leg-rests, anti-tip wheels and backrest, these components are not allowed to fracture, break or permanently deform in order to pass the test. Since such machines are not

available for the test in case, human force will be applied instead to the different components. The components, which will be tested in this test, are the handlebars, the armrests, and the saddle.

The impact strength tests is to determine if the Smartbike would hold-up to hitting objects in the environment while cycling, or maintain strength while mounting. For this, a pendulum with a mass of 10 kg will be used to provide an impact to the frame, front wheel, and handlebars, which are all areas that may come in contact with walls, doors, curbs and similar obstructions. In addition, a soccer ball filled with lead-shot to weigh 25 kg will be dropped into the seat and backrest, to simulate a transfer load as when a person is mounting the vehicle.

And the last, but probably most important of all three strength tests, is the fatigue strength test. In the original fatigue strength recommended from ISO, the wheelchair would be loaded with an appropriately sized test dummy and put to a double drum, or rolling road designed to provide an accelerated test of the wheelchair's durability while driving over moderately rough terrain. The double-drum suspends the wheelchair over two rollers rotating at a linear speed of one metre per second. Slats approximately with 12 millimetres are attached to the rollers in order to simulate door thresholds, sidewalk cracks, stones and similar hazards. According to ISO (Cooper and Cooper, 2004) all manual wheelchairs must withstand at least 200,000 cycles on the double-drum without failure. Since neither a double-drum nor a rolling road will probably be available for the Smartbike test, the vehicle will be ridden in a moderately rough terrain by the author for a total of 12 hours. The second part of the fatigue strength test is the curb-drop test, consisting in lifting the vehicle 50 millimetres from the ground and allow it to free fall onto a hard surface. This process is repeated a minimum of 6,666 times, and the vehicle is to accomplish it without failure. Moreover, it is important to mention that according to ISO (Cooper and Cooper, 2004), a single wheelchair must pass all the three strength tests (static, impact, and fatigue strength tests) in order to be considered acceptable.

6.4.3. C) Braking test

A braking test is extremely important to ensure that the braking system works on a certain way, which will promote the safety of the future users of the Smartbike. The test basically will consist of cycling at a speed of 40 kilometres per hour on a runway of 60 meters and then hit the brakes with full strength. This test will acquaint the author with important information. First it will give an idea of

how fast can the vehicle stop in an extreme situation, for example in case of trying to avoid collision with an obstacle or other cyclist. Then it will also enable a deeper understanding of the vehicle stability during braking. Furthermore, it will show how the braking system affects the comfort of the cyclist when in full effect (if the brake reduces the speed of the vehicle very quickly this will probably force the cyclist to change his position involuntarily resulting on discomfort).

7. Conclusions

The present study had the aim of validating the pertinence of building bicycles specifically designed for the senior population, while giving a continuation to the previously developed study, Smartbike: A Vehicle for the Elderly (Melo, 2007). For this four specific objectives were stipulated, these objectives were, characterize and get acquainted with the senior bicycles available in the market; obtaining concrete information about the seniors and seniors bicycle users in Portugal; getting acquainted with the existing health promoting programs which use the bicycle as an instrument; and in addition also developing a plan for the test of the future Smartbike prototype. The results that would derive from these objectives were thought to be the necessary information to validate the pertinence of building senior bicycles, while at the same time promoting the needed support to progress the Smartbike study into the right direction.

With these four specific objectives in mind, four sub-studies were designed with the intention of achieving them. One sub-study for each specific objective, which in the end all combined would achieve the wanted information. The first objective to be tackled was obtaining information about the potential users of senior bicycles in Portugal and possibly future users of the Smartbike. This objective was achieved by interviewing 40 elderly persons with the help of a structured interview. The second objective was to characterize understand what types of senior bicycles are available in the market, with this purpose an Internet search was conducted and an evaluation of some of the vehicles found was made based on literature concerning the most important aspects in bicycles for seniors. The third objective was to get acquainted with the existing health promoting programs that use the bicycle as an instrument, for this, an Internet search was conducted to find which programs of this kind exist, and then a review of this programs was made regarding the key points. The forth objective was to plan the test of the Smartbike future prototype; this objective was achieved through the design of an adequate test, accompanied by suitable instruments able of evaluating the test performance of the future prototype.

Overall, this pioneer study achieved its aims and made an enhancement to the importance of building, and making accessible to seniors bicycles that are specifically designed for this age group. The results of the study demonstrated the interest of the seniors that do not cycle in starting to cycle again, in case they had access to suitable bicycles, this is information that is extremely relevant not

only for the Smartbike study, but also for those in charge of planning health prevention interventions. Thus, it seems that the introduction of senior bicycles, as instruments for promoting and maintaining the health of the senior populations would be well accepted by the seniors themselves.

A review and evaluation of some of the senior bicycles present in the market was conducted, which is something that has never been done before. This review and evaluation offered a general overview of the senior bicycles available in the market, and showed how some of the features/aspects in these vehicles affect the seniors in a positive, or negative way. The outcomes from this are of great value, not only for the Smartbike study, as it enhances the aspects the Smartbike was already focusing and promotes its future upgrading, but also for those wishing to design and produce appropriate bicycles for the senior populations, as this is very important and exclusive information. In general, it was noticed that all the senior bicycles reviewed had to some extent a lack of design fidelity, meaning with this that they all had features designed with the elderly in mind, however, not all components equipping the bicycles followed that same line. The most common feature intended for seniors, present in the reviewed vehicles was the easy boarding design, and having three wheels. One problematic aspect present in almost all the vehicles was the high price.

Regarding the seniors' opinions in relation to the aspects they most valorize in a bicycle, it is relevant to reemphasize the fact that the seniors attribute most importance to the aspect of safety in a bicycle, followed by the aspect of comfort. This means that the elderly above all look for a vehicle that in first place is safe, but also offers comfort to its user. Not so surprisingly, these are two aspects, which according to theory, should be planned very carefully when designing a bicycle for seniors.

The review concerning the health promoting programs that use the bicycle as an instrument gave a picture of how some governments have acknowledged the importance of the bicycle as a tool for promoting health and active ageing within the elderly and also middle-aged populations. Overall, this review reemphasized the importance of making cycling accessible for seniors, so that this population can gain from the wide range of benefits that this activity can offer them.

Regarding the plan of the test for the Smarbike future prototype, this plan is going to facilitate a lot the process of continuing the development of the Smartbike study, as this tool for testing and

validating the future prototype is already prepared and ready to be conducted. Furthermore, the prototyping phase is taking place at the University of Aveiro integrated as part of a course within the Degree Program in Mechanical Engineering, and should be ready sometime near the end of this year (2009). After this, the plan is to proceed with the testing and validation of the prototype, and eventually if everything goes as planned, possibly trying to find a company that could be interested in commercialize the Smartbike.

Although the interest in bicycles by the governments has been growing a lot in the past decade or so, not only because of its environmental benefits due to being a green way of transport, but also due to its health benefits to the populations, not many efforts have been put in designing and making accessible adequate bicycles for all the populations, including the elderly. The new information brought by this study hopefully will contribute to the promotion of the bicycle as an excellent instrument to promote active ageing and a sustainable environment, as well as, promote the design of safer and more adequate bicycles for the elderly.

7.1. Further development

The Smartbike study is continuing with the prototyping phase taking place at the University of Aveiro and will after that follow into a testing and validation phase of the Smartbike prototype, which could possibly, in a near future, lead to a commercialization of the vehicle.

Concerning only the present study, there are a few aspects that could be further developed in the future. A bigger survey on the potential users of the Smartbike could be conducted, including this time a bigger sample, which would possibly give a more realistic picture about the elderly bicycle users in Portugal. It would be interesting to question more seniors that cycle but that do not belong to a place with a big tradition in cycling. This could probably better explain what motivates the seniors to cycle, as the reasons that motivate seniors living in a place with a big tradition in cycling to cycle, might be the result of influence by other people. In addition, some more specific questions concerning technical aspects of the bicycle, directed to the part of the sample that cycles, could be included, as this would enrich the survey.

One way of improving the review and evaluation of the senior bicycles could be to include the seniors themselves in the evaluation process. This could be done for example if a group discussion with seniors would be hold in the evaluation process. In this group discussion, the seniors taking part would have an opportunity to express their opinions about the vehicles included in the review. This way the evaluation would have the direct input of the seniors themselves, which could make it more complete.

Regarding the test planned for the Smartbike future prototype, the technical part of the test could be improved if the appropriate machines could be available for the strength tests. Because of the not availability of these machines, this part of the test will be made a bit differently trying to recreate the original ISO strength tests.

A considerable number of governments around the world already have acknowledged the economic, social and environmental benefits of not focusing so much on a car-dependent society and started to increase the cycling's modal share, this is very positive. However, this could have even better results if this change would also better include the elderly citizens. This inclusion could be promoted, for example, through programs with the aim of reintroducing cycling to the senior citizens, and through policies with the aim of promoting the development of senior bicycles, as well as, its accessibility to the seniors.

The results obtained during this study seem to indicate that the bicycle could be used as a valuable tool to promote activate ageing within the elderly and middle-aged populations, as well as, offering the seniors a safe and sustainable way of independently moving around, consequently improving their quality of life. Taking this in consideration, it could be of great interest for the policy and decision makers, to begin including the bicycle in their agenda when planning services for the elderly and general transportation infrastructures. One of the most important ways of encouraging the use of the bicycle is through the construction of a better cycling infrastructure. In addition, government authorities would benefit a great deal by implementing health-promoting programs using the bicycle as an instrument, like the ones previously review in this study.

As far as further development considering the planning of services for the elderly, it would be beneficial to include cycling in the programs of activities conducted in elderly institutions, this could

be possible by introducing the seniors to bicycles that are specifically designed for them, in combination with adequate cycling infrastructures implemented in the seniors' environment, including the surroundings of the institutions.

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9. Appendices

9.1. Appexdix 1: Structured Interviews for the Survey on the Portuguese Potential Users of Senior Bicycles

9.1.1. Entrevista estruturada para os sujeitos que andam de bicicleta

1) Idade

2) Sexo
H/ **M**
3) Com que regularidade anda de bicicleta?
   1) **Todos os dias**
   2) Algumas vezes por semana
   3) **1 vez por semana**
   4) Mais do que 1 vez por mês
   5) **Menos de uma vez por mês**

4) Porque motivo anda de bicicleta?
   1) **Meio de transporte**
   2) Prazer
   3) **Para fazer exercício**
   4) Só para curtas distancias
   5) **Outro, qual?**

5) Tem conhecimento da existência de bicicletas especificamente concebidas para pessoa séniores?
Sim/**Não**

a) Se sim. Já alguma vez pensou em comprar uma bicicleta desse género? Sim/**Não**
b) Se não. Consideraria comprar uma bicicleta especificamente concebida para pessoas séniores?Sim/**Não**

6) Em caso de resposta negativa. Porque não?

7) Em caso de resposta positiva. Que valor estaria disposto a pagar por uma bicicleta para séniores?
-200 / **200-300** / 300-500 / **500-700** / 700-1000 / **+1000**

8) Ordene os seguintes aspectos por ordem, do mais importante para o menos importante.

a) Segurança ☐
b) Conforto ☐
c) Aspecto ☐
d) **Preço acessível** ☐

9) Já teve algum acidente de bicicleta?
Sim/**Não**

10) Gravidade do acidente?
Não foi grave / **Grave (teve de ir ao hospital)** / Muito grave (teve de ficar internado no hospital)

9.1.2. Entrevista estruturada para os sujeitos que não andam de bicicleta

1) Idade

2) Sexo
H / **M**

3) Que idade apróximadamente tinha quando deixou de andar de bicicleta?

4) Porque motivo deixou de andar de bicicleta?
a) Comprou outro meio de transporte (carro, moto etc)
b) Começou a usar os transportes públicos
c) Motivos de saúde
d) Teve um acidente de bicicleta e depois disso nunca mais andou de bicicleta
e) Nunca andou de bicicleta com regularidade
f) Por motivo de necessitar de viaturas auto para viajar com mais rapidez para longas distancias
g) Outro. Qual?

5) Consideraria começar de novo a andar de bicicleta se tivesse uma bicicleta que satisfazesse as suas necessidades como ciclista?
Sim / **Não**

6) Tem conhecimento da existência de bicicletas especificamente concebidas para pessoas séniores?
Sim/**Não**

a) Se sim. Já alguma vez pensou em comprar uma bicicleta desse género? Sim/**Não**
b) Se não. Consideraria comprar um bicicleta especificamente concebida para pessoas séniores? Sim/**Não**

7) Em caso de resposta negativa. Porque não?

8) Em caso de resposta positiva. Que valor estaria disposto a pagar por uma bicicleta para séniores?
-200 / **200-300** / 300-500 / **500-700** / 700-1000 / **+1000**

9) Ordene os seguintes aspectos por ordem, do mais importante para o menos importante.

a) Segurança ☐
b) Conforto ☐
c) Aspecto ☐
d) **Preço acessível** ☐

9.2. Appendix 2: Interview for the Smartbike Future Prototype Test

1) Código do sujeito			
2) Idade			
3) Sexo	M	F	
4) Pratica alguma actividade física regularmente?			
5) Se sim que actividade(s)? E com que regularidade?			
6) Anda de bicicleta com regularidade?			
7) Se sim, com que regularidade?			
8) Quando foi a última vez que andou de bicicleta?			
9) Qual a sua opinião sobre a Smartbike em comparação com uma bicicleta normal?			

10) Encontrou algumas dificuldades ao utilizar a Smartbike? Que tipo de dificuldades?
11) Se tivesse que apontar dois problemas na Smartbike, quais seriam esses problemas?
12) Encontrou algumas vantagens na utilização da Smartbike em comparação com uma bicicleta normal? Que tipo de vantagens?
13) Em termos de força necessária para pedalar, qual foi a sua impressão sobre a Smartbike?
14) Encontrou alguma dificuldade em montar-se ou dismontar-se da Smartbike?
15) Achou a Smartbike confortável?

16) A Smartbike oferece ao ciclista a possibilidade de se sentar de uma forma mais direita (ergonomica) do que uma bicicleta normal. Gostou dessa posição?
17) Em termos de condução? Na sua opinião foi dificil/complicado controlar/manobrar a Smartbike?
18) Sentiu algum receio ao experimentar a Smartbike? Que tipo de receio(s)?
19) Considera a Smartbike um veículo apropriado para pessoas idosas?
20) Porquê?
21) Considera que o aspecto da Smartbike é diferente? Porquê?

22) Pode o facto de a Smartbike ter um aspecto tão diferente de uma bicicleta normal afectar a sua aceitação por parte das pessoas?

9.3. Appendix 3: Observation Form for the Smartbike Future Prototype Test

Subject's code:

Age:

Gender: M/F

Ride regularly: Yes/No

Test: 1a) Mounting and dismounting the vehicle

Mounting the Smartbike

1) Does it seem complicated for the subject to understand how to mount the Smartbike?
2) Does any part in the Smartbike get on the way making the mounting process difficult?
3) Looses balance when mounting the Smartbike?
4) Finds it uncomfortable?
5) The subject looks afraid?

Starting the Smartbike

1) Does it seem like the subject has to put a lot of effort/strength to start the Smartbike?
2) The subject looks afraid?

Cycling with the Smartbike

1) Does it seem complicated for the subject to control the Smartbike?
2) Is the subject able to cycle in the intended direction?
3) Does the subject swerve out of the lanes?
4) Does the subject look relaxed?
5) The subject looks afraid?
6) Does it seem like the subject has to put a lot of effort/strength to cycle with the Smartbike?

Dismounting the Smartbike

1) Does it seem complicated for the subject to understand how to dismount the Smartbike?
2) Does any part in the Smartbike get on the way making the dismounting process difficult?
3) Looses balance when dismounting the Smartbike?
4) The subject looks afraid?

Test: 1b) Circling and changing direction

1) Does it seem complicated for the subject to control the Smartbike through the course?
2) Does the subject swerve out of the lanes?
3) Does the subject look relaxed?
4) Does the subject keep a good posture when curving with the vehicle?

Test: 1c) Straight-line control

1) Does it seem complicated for the subject to control the Smartbike through the course?
2) Does the subject swerve out of the lanes?
3) Does the subject look relaxed?

Test: 1d) Weaving and maneuvering

1) Does it seem complicated for the subject to control the Smartbike through the course?
2) Does the subject hit any obstacles?
3) Does the subject look relaxed?
4) How is the vehicle stability when going through the course?
5) Does the subject seem afraid of falling from the vehicle?

Test: 1e) Stopping test

1) Is the subject able to bring the vehicle to a complete stop within the last 5 meters?
2) Does it seem like the vehicle braking system is too sudden or too slow in responding?
3) Does the subject keep is normal posture when braking?
4) How is the vehicle stability when braking?
5) Does the vehicle drift?
6) Does the subject seem afraid?

Test: 1f) Short radius turning

1) Does it seem complicated for the subject to control the Smartbike through the course?
2) Does the subject swerve out of the lanes?
3) Does the subject look relaxed?
4) Does the subject keep a good posture when curving with the vehicle?
5) How is the vehicle stability when doing tight turns?

Test: 1g) Uphill test

1) Is the subject able to cycle all the way to the top?
2) Does it seem challenging for the user to cycle the 30 meters uphill to the top?

9.4. Appendix 4: The Smartbike[1]

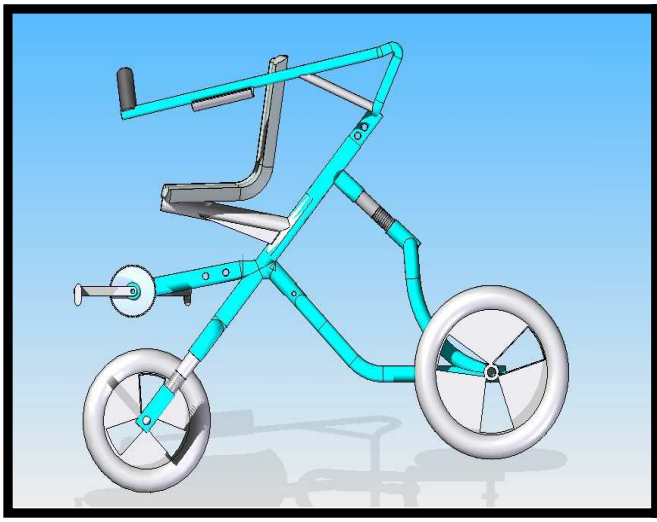

Figure 1. Smartbike side view

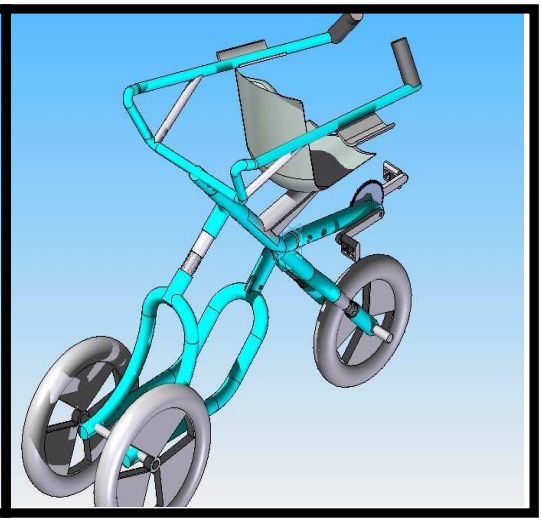

Figure 2. Smartbike isometric view back

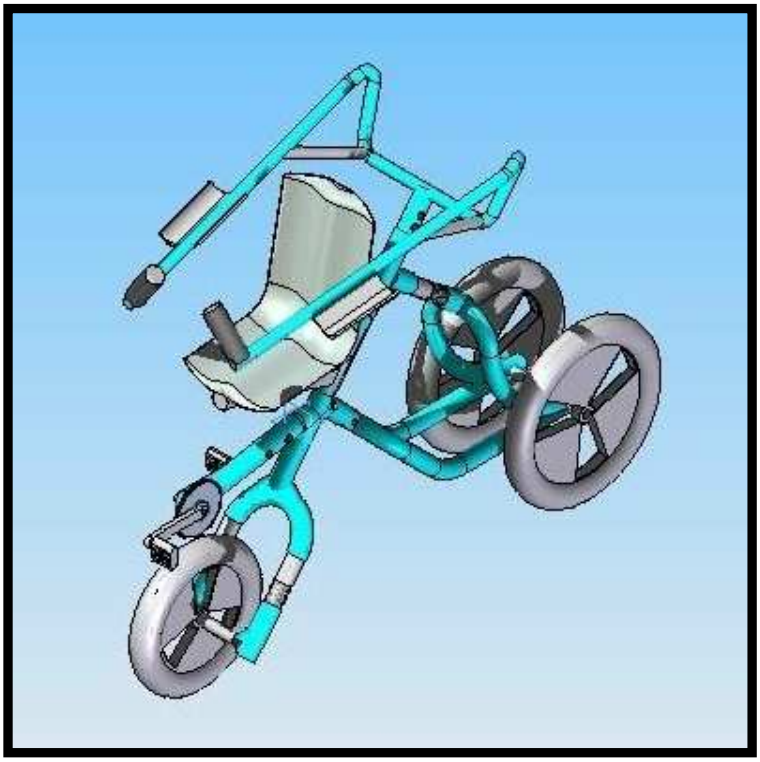

Figure 3. Smartbike isometric view front

[1] Melo, 2007

9.5. Appendix 5: The Smartbike Model for Analyses[2]

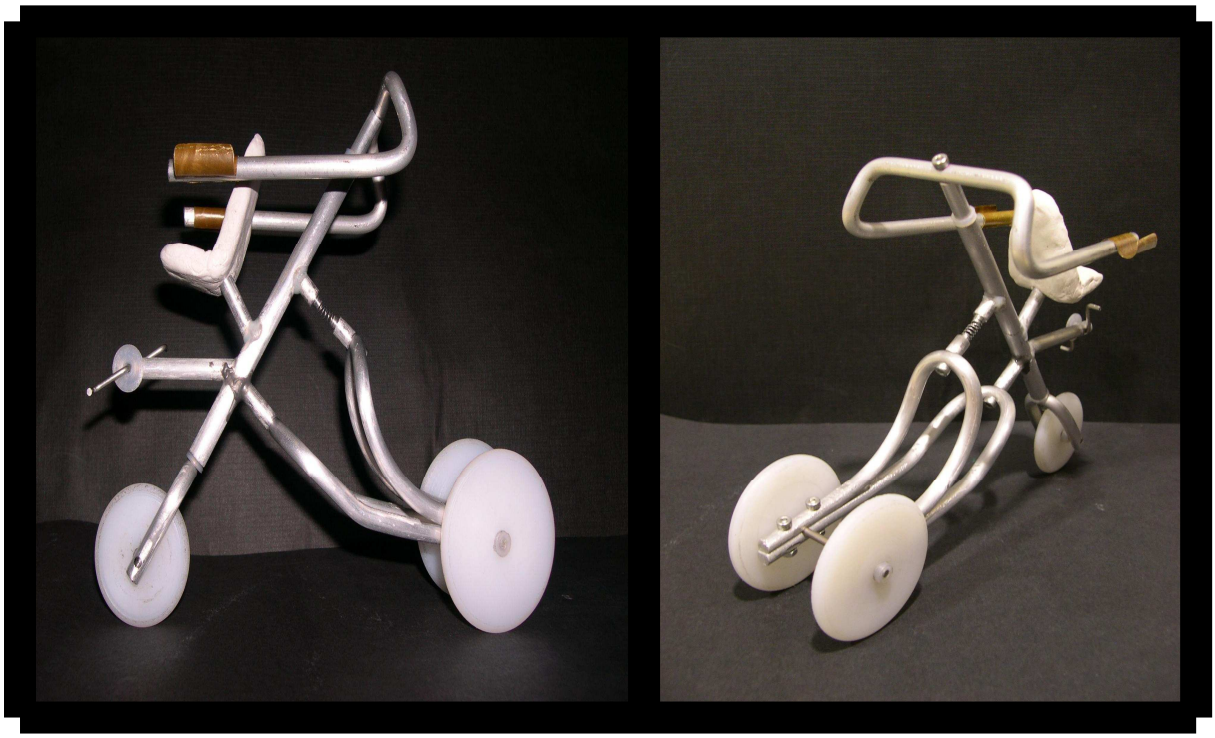

Figure 1. Smartbike model side view Figure 2. Smartbike model isometric view back

Figure 3. Smartbike model isometric view front

[2] MIEM, 2009