

Design Research on Outdoor Fitness Equipment for Cognitive Exercise

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ABSTRACT

Medical treatment for cognitive disease leaves much to be desired, it is necessary to nudge the wide elderly to join cognitive exercise in their daily life. Though the existing cognitive-related designs mostly following the principles of cognitive training, it may be more benefits of the elderly to exercise their cognitive functions of the principle of multi-mode exercise. Outdoor fitness equipment (OFE) includes equipment for different exercise type and is popular with the elderly. Elderly people do exercise to keep their physical health, but little attention is paid to their cognitive health. Research were mainly made from five exercise dimensions on the OFE use of the elderly: Frequency, Intensity, Type, Time (FITT) and Fun, and then suggestion has been given from the layout planning, visual communication and interaction mode of the OFE to nudge better cognitive exercise effect.

Keywords: Outdoor fitness equipment, Cognitive exercise, The elderly

INTRODUCTION

Cognitive diseases have seriously affected individuals and society. Alzheimer's disease, the most widely known cognitive disorder, saw a 145% increase in fatality rates between 2000 and 2017, while mortality rates from heart disease and stroke which also common among older adults have fallen by 9% and 13%. And spending in 2019 for people age ≥ 65 years with dementia are estimated to be \$290 billion (Alzheimer's Association, 2019). World Health Organization (WHO, 2016) predicts that the total number of dementia patients is projected to increase to 82 million in 2030 and 152 million in 2050. Since cognitive disorder is an irreversible and progressive disease that cannot be completely cured and with oblivious early symptoms, prevention and early intervention are the best means of cognitive disorder treatment (Petersen, 2016). It means that some non-medical measures should be taken by the government to nudge the wide elderly maintain cognitive health.

Outdoor Fitness Equipment (OFE) was installed by government to provide different types of exercise equipment for free and is popular with the elderly. But few people observe that multi-modal exercise is one of the effective prevention and intervention measures for cognitive disorder. Meanwhile, most elderly people have formed the habit of daily exercise to keep their physical health but little attention has been paid to cognitive health. Thus, the existing OFE without taking cognitive exercise into the design consideration may

mean missing a good opportunity for intervention. This paper will start from the rationality that the elderly getting cognitive exercise through multi-mode exercise, and then explores how to 'nudge'(Thaler and Sunstein, 2008) the elderly to get more cognitive exercise through the design adjustment of OFE.

BACKGROUND

Cognitive Function

The occurrence of cognitive impairment is a complex process involving multiple factors that cannot completely prevent. The Montreal Cognitive Assessment Scale which is widely used in clinic including eight cognitive domains: attention, concentration, executive functions, memory, language, visuospatial skills, abstraction, calculation and orientation (Harkness, Demers, Heckman and McKelvie, 2011). Older people experience more cognitive decline than younger people in many cognitive domains, while there are also individual differences in the original cognitive function state and decline rate of the elderly (Wilson et al., 2002). When single or multiple of the cognitive functions decline faster than cognitive aging, it indicates that there may be cognitive impairment. So comprehensive cognitive domain should be concerned in cognitive impairment prevention. And among all kinds of non-drug intervention, cognitive training and exercise therapy are the most studied method that could be used on normal people for cognitive exercise.

Cognitive training is based on the principle of cognitive neuro-plasticity, and it is domain-specific. Memory domain training, for example, there is picture recall, number games, face memory etc. Many clinical trials and meta-analyses have shown that cognitive training can effectively improve cognitive performance of healthy elderly people. Other scholars (Boot and Kramer, 2014; Sala and Gobet, 2019), however, thought that the faster response time and higher accuracy reported by most cognitive training studies may due to continuous training on specific tasks helps trainees develop strategies to solve similar tasks, does not mean that cognitive function itself is enhanced. Besides, there are also neuroimaging studies (Dahlin et al., 2008) showed that older adults require more extensive training to trigger neurological changes and cognitive transfers than younger adults.

Exercise therapy is also known as exercise intervention or physical activity. It is major components of medical physical therapy, referring to training methods that promote sensory and functional recovery by repetitive use of instruments, free hands or individual strength. Meta-analysis of physical activity intervention studies for adults over 55 years of age published between 1966 and 2001 found that exercise effects could be observed in a variety of tasks and cognitive processes (Colcombe and Kramer, 2003). Other scholars (Erickson et al., 2011) demonstrated this by observing an increase in the volume of the brain's hippocampus. Exercise has also been recognized as an important protective factor of cognitive function due to the reduction of cardiovascular risk factors (Fillit, Nash, Rundek and Zuckerman, 2008). Besides, some studies (Voss et al., 2010) have shown that exercise training may have a greater overall impact on the efficiency and flexibility of regional

network interactions in the brain in older adults, thus means less domain specificity.

Cognitive Exercise Product

The existing products cater to cognitive exercise are mostly cognitive training principle-oriented, and children's educational toys are the largest category. Most of the cognitive exercise products for elderly people are modified from children's educational toys, by simply adjusting the appearance. For example, the assembled toys are changed from cartoon characters to retro item such as phonographs, dial phones. However, there is huge difference between the needs of the elderly and children. The controversy surrounded the improvement of cognitive training to untrained tasks may be not such a big deal for adolescents who aim to improve academic performance on certain tasks, but for older adults who need to maintain overall cognitive health, it cannot be ignored. Household cognitive training software, another kind of cognitive training product, is more comprehensive and systematic, but with insufficient compliance and low popularity rate. Household cognitive training software requires people to spend a lot of time alone each day focusing on repetitive and boring content, which is definitely hard to get used to. Moreover, for many older people, there is even a barrier to use such software independently.

Though few cognitive exercise products use the principle of exercise therapy, it might be the more appropriate way to prevent cognitive diseases for the elderly. Compare with cognitive exercise, physical exercise is widely valued in the elderly and exercise habit have been built on, it means that by adjusting the details of the existing exercise behavior can we nudge the elderly to get better cognitive exercise. Moreover, acting on the brain structure make exercise get the recovery and protection effect that cognitive training cannot achieve. Though exercise therapy may limitation exist in improvement extent, it can simultaneously acting on various cognitive domains. And experts consensus recommends multi-modal exercise to get better effects.

Multi-Modal Exercise

Multi-modal exercise refers to exercises involving two or more forms of exercise, for instance, aerobic exercise and resistance training, balance training and flexibility training (Baker, Atlantis and Fiatarone Singh, 2007). It's different from mind-body exercise such as Tai Chi and yoga. Systematic review of a meta-analysis by Northey (Northey et al., 2018) found that physical exercise, including moderate-intensity aerobic exercise and resistance training, improved cognitive function in older adults regardless of cognitive baseline status. A large number of control trials (Casas-Herrero et al., 2019), meta-analyses and review studies (Sáez de Asteasu et al., 2017) have also shown that multi-modal exercise has higher cognitive promotion gain comparing with single aerobic exercise. In addition, differences effect on different types of exercise in certain cognitive domain, though due to the limitations of the current human experimental designs, such differences cannot be fully determined. Thus, expert consensus (Cai et al., 2021) advocated multi-modal exercise to improve cognitive function at least three times per week, 45-60

minutes of moderate intensity each time, with 10 minutes balance and flexibility warm-up, 15-25 minutes of aerobic exercise, 10-20 minutes of resistance exercise, 10 minutes of relaxation should be involved.

Outdoor Fitness Equipment

To meet the needs of rising aging populations, parks and other public spaces in Asia, Europe, and North America have installed significant numbers of OFE and still keep installing and updating. OFE area was originally built as a public facility to improve citizens' physical fitness. With the extension of civil needs, educational and entertaining OFE such as chess and seesaw has been slowly developed. Typically, an OFE area consists of multiple equipment stations for different exercise types, such as cardiopulmonary endurance, muscle strength, flexibility and so on. Each type has equipment for different parts of the body. The arm wheels station, for example, is designed to improve flexibility focusing on the upper limb area (Chow, 2013). In many cities, the proportion of smart OFE is increasing. Smart OFE can show the use time, heart rate, calorie consumption and other data. Also, basic functions such as adjusting resistance index can be used through physical buttons, while further functions such as video tutorials and personal recording should use with mobile phone.

Through the summary of relevant concepts in the medical field, aerobic exercise refers to the exercise in a long duration (usually more than 20 minutes), smooth and rhythmic. Thus, typical aerobic exercise equipment in OFE should be spinning bike, elliptical trainer, rowing machine and step trainer. Resistance training exercises mainly involves strength training to overcome one's own body weight or equipment, The intensity of single movement is usually higher and put more emphasis on deliberate control of the certain muscle groups such as directed movement. Corresponding to OFE, there are horizontal bars, parallel bars, chest press, leg press, and so on. While flexibility equipment aimed at expanding the range of the joint and ligament, specifically, they are equipment that assisting in stretching movements such as stretch racks, waist twister and pendulum device. Balance exercises refer to static and dynamic exercises that improve postural control(Hui and Rubenstein, 2006) and these often combined with flexibility OFE, as flexibility exercises also work to improve body coordination. Relaxation exercise refers to muscle stretching and massage after exercise. It is essentially coincident with the equipment of flexible exercise in OFE.

RESEARCH

Object And Method

Although OFE provides sufficient equipment for multi-modal exercises, it does not mean that the elderly can achieve cognitive exercise. Thus, further field research follow FITT(ACSM, 2013), involved exercise dimensions on the OFE use of the elderly: Frequency, Intensity, Type, and Time. Besides, attention was also paid on Fun (Burnet et al., 2019) of the elderly in using OFE.

The sports park located in Ershadao of Guangzhou is selected as the observation sites, where there are both pure mechanical OFE and smart OFE. Main research includes: (1) Frequency: over 50 elderly adults will be interviewed about their OFE use frequency; (2) Intensity: 30 elderly people will be measured by Rating of Perceived Exertion (RPE) (Brog, 1982) at the end of their whole OFE journey, and RPE score within 12 to 15 means those surveyed have gone through moderate intensity exercise; the age and heart rate data of 10 elderly people who use Upright Cycle will be recorded, moderate intensity of physical exercise means that their exercise heart rate (HR) should be within 64% to 76% of their maximum heart rate (220-age) (Garber et al., 2011); (3) Type and Time: follow the movement of more than 10 target elderly people in OFE area and record the type and time of the equipment they used.

Result

Frequency Only 4 in 52 elderly people come to OFE less than 3 times per week, most of the interviewees use OFE area more than 5 days per week, and stay for 1 to 2.5 hours each time.

Intensity 30 elderly people who had finished their whole OFE journey were invited to do RPE, and over 93% of their scores were between 12 to 15. It seems that elderly people end their OFE journey spontaneously when they meet the moderate intensity exercise. 6 of 10 people met moderate exercise intensity in using Upright Cycle, while 3 higher and 1 lower. The main reason for the lower heart rate may be related to the short use time. Though half of these 10 subjects have adjusted the resistance index, overwhelming majority of the interviewees said that they have no idea about the resistance index and lasting time that suit for them. Chen² using upright cycle in high intensity but short time, which more seems to doing anaerobic exercise, and this has led to her high heart rate. Zhao found that her fast heart rate took a long time to calm down after she stopping use the Upright Cycle. Not only does this imply potential life danger, but it could also represent cognitive impairment caused by excessive fatigue.

Type and Time Table 2 was the OFE types and time using record of 11 elderly people. Exercise types that meet the time require were marked green, and types that did not take any minutes was marked red. It is great pity that none of the elderly had met the requirement of cognitive exercise recommendations, even though most of the elderly had been using the OFE for nearly 45–60 minutes. There were even 3 elderly people absent from some type of exercise. It means that the allocation of time for different types of exercises should be adjusted. Besides, using multiple equipment but each equipment for only short time is the general characteristics of OFE using of the elderly. They tend to choose the equipment in their sight at will. Moreover, although the instructions on smart OFE clearly marked out the exercise type and the certain muscle groups that are activated through pictures, people seldom pay attention to these and know little about the value of these information, let alone the consciously combination of exercise equipment. For example, Code 2 and Code 6 use multiple strength exercises for the arms without

Table 1. Record of heart rate when using upright cycle.

Name	Gender	Age	Time(min)	Resistance index (1–10)	HR range of moderate intensity exercise	Exercise HR
Zhang1	Female	83	5:00	1	87–104 bpm	99 bpm
Lv	Female	57	3:17	2	104–124 bpm	117 bpm
Liu	Male	66	1:29	1	98–117 bpm	94 bpm
Chen2	Male	63	5:38	1	100–119 bpm	114 bpm
Zhu	Female	71	8:02	2	95–113 bpm	118 bpm
Sun	Male	66	4:22	4	98–117 bpm	114 bpm
chen2	Female	58	2:11	6	103–120 bpm	123 bpm
zhang2	Male	63	4:34	1	100–119 bpm	107 bpm
Zhao	Female	67	8:18	3	97–116 bpm	128 bpm
Shan	Male	64	2:27	1	99–118 bpm	100 bpm

Table 2. Record of OFE using type and time for the object.

Code	Flexibility and Balance (min)							Aerobic (min)				Resistance (min)					Total Time
	F1	F2	F3	F4	F5	F6	F7	A1	A2	A3	A4	R1	R2	R3	R4	R5	
1	3	7	4	6.5	5	5	/	/	4.5	8	/	/	4	/	8	/	55
2	2.5	3	5	3	6	6.5	6.5	/	4	/	8	/	/	7	4	/	55.5
3	5	/	/	8	/	/	/	/	/	6	/	6	/	18	3	11	57
4	6	3.5	2.5	/	/	/	5.5	9	4	8	/	4	8	/	/	/	50.5
5	5	11	9	5	7	/	/	4.5	5	/	4	/	7	/	/	/	57.5
6	/	/	/	3.5	13	/	2	5	9	6	2	/	/	13	8	/	61.5
7	4	3.5	6	/	8	/	5	6	8	6.5	2	/	/	/	/	/	49
8	/	2	5	5	7	/	/	6.5	/	5.5	/	3	6	/	/	6	46
9	6.5	3.5	3	5	/	10	/	/	/	20	/	/	/	/	/	/	48
10	/	3	/	2.5	5	6.5	8.5	3	4	8	3	3.5	/	/	4	5.5	56.5
11	5.5	6	9	/	/	2	3	/	/	/	/	10	7	/	/	/	42.5
Total Time	37.5	42.5	43.5	38.5	51	30	30.5	34	38.5	68	19	26.5	32	38	27	22.5	

F1:Waist Twister; F2: Arm Wheels; F3: Shoulder Wheels; F4: Stretch Racks; F5: Air Walker; F6: Back Roll; F7: Hip Pendulum; A1: Elliptical Trainer; A2:Rowing machine A3: Spinning bike; A4:Upright Cycle; R1: Chest Press; R2: Leg Press; R3: Horizontal Bar; R4: Parallel Bar; R5: Sit Up Bench

any resistance exercises for other areas such as the legs and stomach. From the view of the users number and total time of single equipment, Spinning bike stations become the most popular OFE due to its build-in music device and progress display, especially comparing with the movements resemblance Upright Cycle.

Fun It is worth mentioning that more than 30% of the elderly people in OFE area listen to music by their headphones, phone speakers or portable Bluetooth speakers when exercising. And these people (such as Code 3 and Code5) tend to use single equipment for longer time than those who do not listen to music. More Interestingly, through the observation of the elderly who play music publicly, we found that their shift between equipment always synchronizes with the switch of song, especially with significant change in style or rhythm. Interviewee figured this to the adjusting of body rhythm

and also some kind of ‘obsessive-compulsive disorder’. Besides, exercise in similar time creates close friendships among the elderly, Code1 and Code2 have even been mistaken for mother and daughter. Maintaining friendship in turn gives them great motivation to keep regularly OFE exercise. Last but not least, the elderly prefer physical interaction such as buttons. They are common to associate the use of mobile phone applications with troublesome and complex operations, thus, even if they have some interested in further functions, most of them are reluctant to try.

DESIGN ADVICE

First, it is better to use different colors to distinguish different types of equipment instead of using text instruction, thereby intuitively conveying the message to the elderly that they are using different types of equipment. And music elements are worth attention when adjusting the time allocation of different exercise types. For example, time of each exercise type can be calculated and indicated by portable wearable devices such as wristbands, and music for specific exercises can be activated by these devices within time. Though it is common to use apps interaction for these functions, caution is needed here. Priority is given to entities interactions and minimal step even if functionality may need to be simplified.

In addition to improving the duration of some elderly people’s flexibility exercise, for most elderly people who have done enough flexibility exercise, the time allocation between warm-up flexibility exercise and relaxation flexibility exercise also needs to be adjusted. It is better to divide OFE of flexibility exercise into two parts: equipment for opening joint mobility such as Stretch Racks and Shoulder Wheel are placed at the beginning of the moving path, while muscle massaging equipment like Back Roll and equipment with larger mechanical inertia such as Air Walker might be placed at the end of the moving path.

For aerobic OFE, it would be better to change timer mode that starting from 0 into similar form as 5-minute countdown timing for one group, which would nudge more users to stop on the appropriate time, thus reducing invalid exercise or hard high heart rate. Then reduce the high resistance index could prevent from entering anaerobic exercise. In addition, the elderly use aerobic exercise in obvious fluctuation speed since steady tempo did not been highlighted on aerobic OFE. Add graphic or audio indication like pitch calibrators might work.

Though great majority of elderly people do sufficient time of resistance exercise, haphazard use of OFE result in the situations that part of their body muscles are over-exercised while the other parts of the body muscles are not activated and rebuilt. Since functional and structural adaptations of the musculature are moderating factors for the neurocognitive status, it would be better to divide the resistance OFE according to body parts such as hand, back and leg, and then place along the moving path. This might virtually conduct the elderly use resistance OFE of more body parts in the process of moving.

CONCLUSION

Based on the characteristic and need of the elderly, the existing product forms of cognitive training principle-oriented were abandoned, and exercise therapy is chosen as the principle of cognitive exercise. Then Research has been conducted on the Frequency, Intensity, Type, Time and Fun of elderly's OFE exercise, and adjustment advices has been given on the layout planning, visual communication and interaction mode of the OFE. In general, this research provides another track to the design of cognitive exercise products, and maybe a little inspiration for the products design of other diseases prevention.

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