

Article

Exercise for People with Acquired Brain Injury: An ICF Perspective

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Featured Application: This paper sheds light on the intention to design exercise programs for people with acquired brain injury. This proposal has a direct practical application with athletes with acquired brain injury with whom we work with every day.

Abstract: Exercise is an important element in the process of recovery from an acquired brain injury (ABI). However, specific guidance for exercise prescription and interventions in this population are missed. The aim of this study was to establish the key parameters to design and implement exercise programs based on the International Classification of Functioning, Disability, and Health (ICF) domains. A panel of experts that consisted of 13 professionals from neuro-rehabilitation centers evaluated the key parameters of this original proposal. The Heinemann methodology was used for all qualitative analyses. Additionally, Cronbach’s alpha was applied to the statistical analyses. According to the results, Cronbach’s alpha (0.97) indicated excellent internal consistency, and the experts perceptions ratified the proposed criteria to develop exercise programs for people with ABI. The proposed key parameters for the development of exercise programs for people with ABI based in ICF domains (body functions, activity—participation and environmental factors) bring a new, solid, and innovative tool for methodological design of these programs in sub-acute and chronic rehabilitation settings.

Keywords: adapted physical activity; international classification of functionality; design exercise



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1. Introduction

Acquired brain injury (ABI) is one of the leading causes of disability among people, the first etiologies being stroke, followed by traumatic brain injury [1,2]. ABI frequently causes physical, cognitive, emotional, behavioral, and sensory deficits that affect daily life irrespective of the etiology [3,4], causing a deterioration in functional capacity, and resulting in a sedentary lifestyle [5] and a low quality of life [6].

In this respect, neuro-rehabilitation strategies during the acute, subacute, and chronic phases of ABI are based on comprehensive and multidisciplinary approaches with little differences between etiologies [7,8]. In fact, Rehabilitation Centers include people with different ABI etiologies who receive group therapies for physical, cognitive, and behavioral recovery, and also individual therapies according to their abilities, their evolution moment, or the specific brain damage [9]. This heterogeneity of the collective appears as not decisive in exercise and sport programs, in which the specific personal functionality and participation possibilities are key in order to establish adequate guidelines to promote health-oriented exercise programs [10].

To achieve the best rehabilitation outcomes it is necessary to take into account factors that can influence motor skills, social interaction skills, and age [11], and to maximize its effectiveness it is crucial to individualize treatment plans [12]. Despite all the above, more evidence is needed to determine the best strategies during the subacute and chronic phase [13]. It is remarkable that during the subacute phase the multidisciplinary team will set the goals for the recovery, while in the chronic phase the person usually returns to his environment and can have greater autonomy on their own decisions and choices [14].

Exercise, defined as a structured, planned, repetitive, and directed PA [15] is considered essential for functional recovery in people with ABI [16–18]. For this reason, exercise programs (stressing aerobic, strength, and multicomponent programs) have gained importance in rehabilitation programs along recent years, especially during subacute and chronic phase given its positive benefits in improving functional capacity, reduction of sedentary behavior and, therefore, a lower risk of secondary diseases associated to ABI [19,20].

While positive benefits of exercise as content of rehabilitation programs for people with ABI have been demonstrated, scarce research is available dealing with evidence-based recommendations for its prescription, planning, and implementation. Up to now, research suggest there is no consensus on the recommendations for exercise design programs, finding great diversity of training model as well as the characteristics and components of these interventions. For instance, diversity in training content (exercise type) is common in the studies using exercise in ABI rehabilitation programs: strength training shows improvements in functional capacity [21,22], but also aerobic exercise and multicomponent intervention [16,23] have been used with positive results for functional capacity enhancement. There is also diversity in studies dealing with environmental context, where the exercise is implemented and their positive results on functional capacity are determined, highlighting aquatic medium [19,24], treadmill [25], or virtual reality [26,27], but no clear conclusions have been made in the relevance of a given exercise context with respect to the rest of them dealing with better results on functional capacity of people with ABI. Exercise is also a key tool to improve cognitive function [28] and health-related quality of life (HRQoL) [20,29,30].

In people with disabilities, the achievement in the design and the implementation of an exercise program involves the adequate selection of contents, goal-setting, and the correct pedagogical practices to stimulate participation [31,32] and adherence to the programs [33]. Although exercise programs have been described for people with ABI in the subacute and chronic phase, it is necessary to generate a consensus on which exercise aspects most benefit people with ABI. This endeavor will allow the design and implementation of exercise programs that will be effective, person centered, and evidence based.

The International Classification of Functioning, Disability, and Health (ICF; [34] organizes information into two parts (functioning and disability and contextual factors); the first part covers the body structures and functions, activities, and participation, and the second part concerns the persons' environment as well as his or her personality, ensuring that everything concerning the person (with disability) is taken into account; so it is a powerful framework that has shown effectiveness in addressing the health status of people with disabilities in clinical setting, policy, and social care [35,36], and also for athletics classification [37]. In people with ABI, the ICF approach is used to assess the impact of the damage [38] in the neuropsychological field [39] and in the exercise field; ICF provides the key tool in identifying factors that impact participation in physical activity among people with disabilities [40,41], and the effects of adaptive sports has been investigated according to the domains of the ICF, finding significant effects except in the environmental factors [42]. For all of the above mentioned, the aim of this study was to establish the key parameters to design and implement exercise programs in people with subacute and chronic ABI, using ICF classification as a framework.

2. Materials and Methods

Our experiment represents a cross-sectional survey. The authors’ institution ethical committee approved the protocol for this investigation. The study was approved by the Ethics Committee of the Polytechnic University of Madrid. Data collection procedures were performed according to the Declaration of Helsinki [43].

2.1. Participants

The members of the expert panel were selected according to a multidisciplinary neuro-rehabilitation model [8], with regard to the professionals involved in the process of ABI rehabilitation during the subacute and chronic phase. All professionals bring a key point of view to take into account in the design of an exercise program that addresses critical considerations for people with ABI. Twelve professionals, panel experts, from multidisciplinary neuro-rehabilitation centers of Spain, participated in the study: two rehabilitation physicians, two physiotherapists, two occupational therapists, one speech therapist, two neuropsychologists, two sport instructors, and a social worker. This sample is representative of the specific rehabilitation model related to the treatment and approach for people with ABI. To be included in the study, evaluators must have been working with people with ABI at the time of the study and must have had at least 5 years of experience with ABI specifically dealing with traumatic injuries, stroke, brain tumors, brain anoxies, and brain infections. Each participant received an anonymous report with the results of the study. The participants contributed their perceptions between November 2019 and January 2020.

2.2. Design

In order to develop the criteria proposal (Figure 1), three phases were defined: (1) design, (2) application, and (3) assess the relevance of the proposed key parameters for exercise with ABI for exercise professionals. This original proposal was designed based on the ICF domains by experts in exercise for people with ABI.

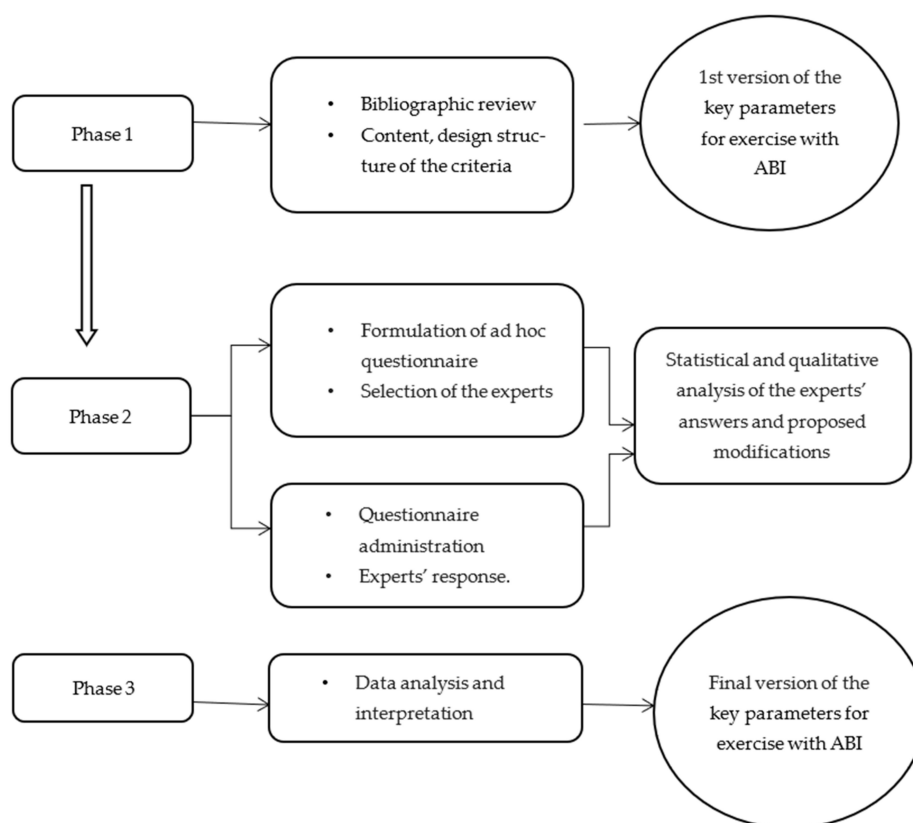


Figure 1. Research Design: phases and methodological development of the study.

For each domain, an ad hoc questionnaire was designed to determine the relevance and adequacy of each item using a 5-point Likert scale (from 1 [totally disagree] to 5 [totally agree]), and 15 affirmations to be assessed using a 6-point Likert scale (from 0 [totally disagree] to 5 [totally agree]) related to characteristics of the key parameters.

2.3. Procedure

All the participants were informed of the purpose and methodology of the study, and, after providing written consent, they were sent the designed questionnaire via email by the responsible researcher, including a link with an online form. After completing the questionnaire, the data were stored. The responses were anonymous.

Phase 1: Selection of key parameters

The key parameters selected are a checklist of criteria based on the ICF, created by exercise and ABI experts, which includes the heterogeneity of four deficit areas that are targeted after ABI and how they can be influenced in different environments [19,44–47]. In this regard, the selection of key parameters was based on the subjective and objective parameter of the ABI approach.

Regarding mental function (b1), the following factors were assessed: attentional processes, executive functions, reaction speed, distraction, disinhibition, limitation in dual tasks, lack of initiative, hard time understanding complex orders, and orientation problems [4,48,49]. In sensory functions and pain (b2), the assessed factors were as follows: hearing problems and visual deficits, and the level of detection, discrimination, location, and recognition [38]. In the voice and speech function domain (b3), the following were assessed: aphasia and apraxia speech disorders and dysarthria due to muscle weakness [50,51].

Medical reports that include cardiac or other pathologies are necessary to understand the impact of these domains on the functions of the 1) cardiovascular, hematological, immunological, and respiratory systems (b4); 2) digestive, metabolic, and endocrine systems (b5); and 3) genitourinary and reproductive systems (b6) in exercise practice. The neuromusculoskeletal and movement-related function domain includes hypertonia and hypotonia [52,53], hemiparesis, hemiplegia [54], ataxia [55], and motor apraxia [56]. Finally, the domain containing functions of the skin and related structures includes lack of sensitivity or hypersensitivity to pain [57].

As a result of key parameters selection, a checklist of items was developed. In line with this, Table 1 shows the selected items taking into account ICF body function and structure domains.

Table 1. Checklist Body Function.

Mental Function (b1)
Increase time required for execution of movements
Establish progression in the performance of dual tasks
Simplify task or progressively increase the number of rules to be assimilated
Design exercises or tasks involving both motor and cognitive actions
Select global-specific or specific-global method according to the cognitive deficits
Vary the use of methodological resources (game, exercise, circuit)
Sensory Functions and Pain (b2)
Perform pain-free movement
Use bright colors and varied shapes
Select material locations according to deficits and using auditory or visual references
Regulate sounds and noises before hyperacusis
Voice and Speech Function (b3)
Use visual elements through body expression, pictograms, or images
Use brief explanations, concise feedback, and positive reinforcement during task
Establish keywords that facilitate technical-user communication
Simplify task or progressively increase the number of rules to be assimilated

Table 1. *Cont.*

Functions of the cardiovascular, hematological, immunological, and respiratory system (b4); functions of the digestive, metabolic, and endocrine systems (b5), and genitourinary and reproductive functions (b6)
Control the maximum heart rate Assess possibility if necessary of analysis of the Vo2max through stress test Assess the need to use a heart rate monitor
Neuromusculoskeletal and movement-related functions (b7)
Know the alteration of static and dynamic balance: walking autonomy. Use technical support, do activity in safe and supervised space Assess muscle action and control and control the articular range in which tremor occurs Understand and restrict movement of the joints and works without pain. Upper limb: check possibility of gripping with paretic hand with different materials and positions Lower limb: assess clubfoot, splints or orthotics. Special care in aquatic activities with the possibility of using weights to hold the foot Know the potential for hand-eye and foot-eye coordination Ask the dominant side if has changed due to hemiparesis or hemiplegia Know the alteration of static and dynamic equilibrium: autonomy
Functions of the skin and related structures (b8)
Regulation of water temperature to avoid spasticity Take into account sensory lack on the affected side when making transfers, grips, and supports Check that the auxiliary material does not cause injury to the skin and related structures (Ex: fins with socks) Know if there is hypersensitivity in the affected area and if there is, avoid catching him

Related to limitations and participation restrictions domains, an exercise professional with experience in ABI approach selects the most adequate type of exercise for each person so that he or she can achieve the highest participation rate. In this regard, work on self-esteem serves to improve participation [58] so that the person with ABI chooses to perform activities in an exercise group rather than individually whenever possible [59]. These choices will determine the success of the design and implementation of an exercise program for ABI [47,60] (Table 2).

Table 2. Checklist Activity and Participation.

Activity and Participation
Choose aquatic activity if there is a risk of falling Select different teaching methods to ensure the assimilation of basic concepts Design task that can be performed sitting, standing or moving Evaluate needs and determine ratio for each person Assess the level of involvement in practice and set objectives Generate relaxed and motivating environment Design tasks that have transfer to activities of daily life

Also, according to environmental factors, it was necessary to understand the technological possibilities required to generate support and offer accessibility to people with ABI (Table 3). Additionally, family support, the impact that rehabilitation has on activities of daily living (ADLs) (Table 2); social relationships, the ability to share the experience with peers; and other personal characteristics (i.e., education, gender and age) must also be assessed as factors [61,62]. Finally, it is important to have a certified sport professional design and implement the entire exercise program, and to be connected to a multidisciplinary team [63], because this interaction could improve the approach to ACL in order to take into account all the necessary aspects to provide quality of life to this population.

Table 3. Checklist Environmental factors.

Environmental Factors
Analyze the place of practice ensuring universal accessibility
Incorporate education in values into activities
Know and empathize with the personal situation of each user
Maintain a good relationship with the multidisciplinary team and the family

Phase 2. Formulation ad hoc instrument

To validate the criteria, a questionnaire composed of nine questions was designed: three questions each related to demographic data, workplace characteristics, and professional profile. Five-point Likert scales (from 1 [*totally disagree*] to 5 [*totally agree*]) were designed to be related to the domains described in Table 1. Five-point Likert scales (from 1 [*totally disagree*] to 5 [*totally agree*]) were also used to determine the relevance of ABI criteria for exercise based on 15 affirmations. These affirmations were related to the following topics (adapted from Yoo et al. [64]): feasibility of application; a clear and well-defined objective; content associated with the ICF domains; aspects related to the evaluation of the ABI criteria for the exercise approach; perceived as an important therapeutic tool; scientific bases; sufficient quantity and quality of information; current, contrasted, and updated information; logical structure; clear and simple explanation; efficiently detailed structure; appropriate for the therapeutic approach and relationship exercise; and the relationship between the criteria and ICF domains in relation to the main objective of the study and its applicability.

2.4. Data Analysis

2.4.1. Qualitative Analysis

After data collection, qualitative analysis was performed following the methodology proposed by Heinemann [65]. In the first phase, an intensive floating reading was used to create a general outline of the content and arguments, designing a proposal of identifiable categories in the answers. After this, analysis of phrases and word was done in order to organize a category system. In the second phase, data codification and categorization, and major results, topics, and arguments, were structured by the domains and the experts' profession. According to the codification, the professional occupation of each expert was specified as follows: physiotherapist as "PT," physical activity and sports as "PAS," rehabilitation physician as "RP," neuropsychologist as "NP," speech therapist as "ST," social worker as "SW," and occupational therapist as "OT." Each code also included a number, for example, for the neuropsychologist, expert number one, the codification was "NP1."

2.4.2. Statistical Analysis

Demographic data were analyzed using descriptive statistics. Cronbach's alpha was used to assess internal consistency. According to George & Mallery [66], the following Cronbach's alpha ranges were established: >0.9 is excellent; >0.8 is good; >0.7 is acceptable; >0.6 is questionable; >0.5 is poor; and <0.5 is unacceptable. Media and standard deviation were used to establish average ratings for items. For statistical analysis, Microsoft Excel 2007 and SPSS V26 were used for the data analysis. The significance was set at $\alpha \leq 0.05$.

3. Results

According to qualitative analysis, data analyses showed that only five experts made observations related to all domains. In this regard, we present the experts' perceptions separately for each criterion. Based on the demographic characteristics of the experts, the majority of the experts were females (69.2%). The experts explained that the proposed criteria to develop exercise programs could be a useful tool in the context of the ABI approach.

3.1. Mental Health Functions

Regarding mental health functions in the item related to adequacy of the execution time of movements, ST1 specified that it “would be better to adapt the time, rather than increase it. In some cases, it may be more important to reduce it, depending on the purpose of the task.”

3.2. Pain and Sensorial Functions

RP1 stated, “I do not know if it is in your power to control the regulation of sounds and noises, and in a way, it is also necessary to create habituation to those stimuli.”

In the item related to use of colors and varied shapes, ST1 considered “that you also have to be careful to create chaos with the variety of colors and shapes [. . .] and [they] should be adapted to sensory abilities. Furthermore, it is prudent to “take into account the size of the stimulus.”

3.3. Voice and Speech Functions

ST1 suggested, “It is important to encourage expression since physical activity is often motivating and produces physical and emotional sensations that promote expression.” ST1 also specified, “It’s important to be patient and time for users to communicate without pressure.”

3.4. System Functions

Regarding items about system functions, RP1 related that “a medical certificate should be sufficient, especially in patients who by their neurological pathology in theory are following a control of cardiovascular risk factors.” RP1 also noted, “It’s really not essential, although it’s an excellent positive feedback when it’s available; in individual work environments I think if it can be interesting.”

3.5. Neuromusculoskeletal Functions

PT1 indicated, “In the support of the foot, I consider it important to take into account the support in the use of different surfaces.” In this regard, RP1 explained that “with the equine-varo, the only thing is that they do not slip in the pool.”

RP1 also stated, “I believe that the control of the action and the tremor are very analytical parameters that should not modify an activity in the sports field.” Furthermore, RP1 explained that “the functional approach must prevail.”

3.6. Skin Functions

According to hypersensitivity in the affected area and inability to grip, PT1 considered that “rather than avoiding grips, I would adapt them.” In line with this view, and related to the regulation of the water temperature, RP1 noted, “You cannot always modify the water pool used, and in any case, it differs greatly from the time of activity by the temperature generated by the body itself.”

3.7. Activity and Participation

PAS1 suggested to include “in the design activities the lying position (both prone and supine) to detach ourselves from dependence on the aquatic environment.” PAS1 noted, “I am in favor of referral to the aquatic environment for all the advantages it offers us, but not that this is necessarily linked to the risk of falling.” RP1 suggested “the benefits of water are so many that, if there is a risk of falls, it is preferable to manage the patient as if he were not wandering, before avoiding activities in the aquatic environment.”

Regarding the transfer to ADLs, RP1 explained that “sometimes the patient requires a purely playful sports environment, and that is what gives him quality of life.” In this regard, RP1 suggested that “not always being more independent in ADLs implies a higher quality of life in everyone, sometimes even subtracts.”

3.8. Contextual Factors

According to contextual factors, RP1 suggested that “sometimes the activity is interesting for a selected group of patients who can access it.” However, RP1 explained, “I do not share the generic concept of ‘universal accessibility’ in this specific sense, I asked.” Related to incorporating the work of values in the activities, RP1 considered, “It is a positive thing, but it does not seem essential to me thinking of an environment in which the user is just looking for independence.” However, PAS2 and ST1 considered that values are important in the context of exercise approach. ST1 stated, “Values like autonomy, companionship, and self-esteem are the fundamental ones and it would give a score of five in terms of both adequacy and relevance.”

Related to quantitative analysis, Table 4 indicates the descriptive relevance and the adequacy of the criteria. In this regard, the calculated Cronbach’s alpha (0.97) indicated excellent internal consistency of the ABI criteria for the exercise programs approach.

Table 4. Relevance and adequation per criteria.

Criteria	Relevance		Adequation	
	X	XS	X	XS
Body Function	4.54	0.97	4.46	1.50
Establish progression in the performance of dual task	4.92	0.64	4.92	0.64
Simplify task or progressively increase the number of rules to be assimilated	4.85	0.69	4.69	0.75
Design exercises or task involving both motor and cognitive actions	4.77	0.93	4.77	0.93
Select global-specific or specific-global method according to the cognitive deficits	4.38	1.12	4.38	1.12
Vary in the use of methodological resources	4.69	0.95	4.69	0.95
Use bright colors and varied shapes	5.08	0.862	5.15	0.80
Select material locations according to deficits and using auditory or visual references	4.46	1.33	4.38	1.19
Regulate sounds and noises before hyperacusis	4.85	0.80	4.85	0.69
Use visual elements through body expression, pictograms or images	4.46	1.33	4.54	1.13
Use brief explanations, concise feedback, and positive reinforcement during task	4.31	1.60	4.38	1.56
Establish keywords that facilitate technical-user communication	4.54	1.56	4.62	1.50
Control of the maximum heart rate	4.62	1.50	4.54	1.51
Assess possibility if necessary of analysis of the Vo2max through stress test	5.00	0.82	4.77	1.01
Simplify task or progressively increase the number of rules to be assimilated	4.92	1.19	4.69	1.44
Assess the need to use an heart rate monitor	5.31	0.63	5.08	0.96
Select material locations according to deficits and using auditory or visual references	4.46	1.94	4.62	1.90
Know the alteration of static and dynamic balance: walking autonomy.	4.69	1.25	4.77	1.09
Muscular control	5.00	0.91	5.00	0.91
Understand and restrict movement of the joints and works without pain.	4.85	1.29	4.92	1.26
Upper limb functionality	5.08	1.12	5.08	1.12
Lower limb functionality	5.23	0.73	5.15	0.90
Know the potential for hand-eye and foot-eye coordination	5.15	0.80	5.23	0.73
Ask if the dominant side has changed due to hemiparesis or hemiplegia	4.77	1.90	4.92	0.95
	4.77	0.83	4.69	0.86

Table 4. Cont.

Criteria	Relevance		Adequation	
	X	XS	X	XS
Regulation of water temperature to avoid spasticity	4.92	1.26	4.92	1.12
Regulate sounds and noises before hyperacusia	4.85	0.99	4.77	1.09
Check that the auxiliary material does not cause injury to the skin and related structures	5.08	0.49	4.92	0.64
Know if there is hypersensitivity in the affected area	5.08	0.49	4.92	0.64
Activity and Participation				
Choose aquatic activity if there is a risk of falling	4.38	1.38	4.08	1.50
Select different teaching methods to ensure the assimilation of basic concepts	4.54	1.05	4.62	1.04
Design task that can be performed sitting, standing or moving	5.08	0.64	5.00	0.71
Evaluate needs and determine ratio for each person	5.00	0.58	5.00	0.58
Assess the level of involvement in practice and set objectives	4.69	0.75	4.69	0.63
Generate relaxed and motivating environment	4.54	0.88	4.69	0.75
Design tasks that have transfer to activities of daily life	4.46	4.13	4.62	0.77
Environmental Factors				
Analyze the place of practice ensuring universal accessibility	4.54	0.88	4.54	0.78
Incorporate education in values into activities	4.08	1.04	4.38	0.65
Know and empathize with the personal situation of each user	4.23	0.93	4.38	0.88
Maintain a good relationship with the multidisciplinary team and the family	4.85	0.38	4.92	0.28

The experts rated the 13 affirmations related to the characteristics of the key parameters. Their average ratings for items related to the ability to apply exercise programs to people with ABI ($M = 4.69$, $SD = 0.49$), efficiently detailed and structured ($M = 4.85$, $SD = 0.38$), and appropriate for the therapeutic approach ($M = 4.69$, $SD = 0.49$), were higher than the other evaluated aspects. The items related to feasibility of application ($M = 3.54$, $SD = 0.52$) and physical format and presentation ($M = 3.54$, $SD = 0.52$) showed the lowest averages. For qualitative data, 5 of the 13 participants made some qualitative observations related to all the domains. The panel stated that the proposed criteria for the key parameters based on ICF domain is appropriate to design and implement exercise programs for people with ABI in sub-acute and chronic rehabilitation settings.

4. Discussion

The aim of this study was to provide an original proposal of key parameters for exercise professionals to design and implement exercise programs in people with ABI, using the ICF framework, which has been used previously by other authors when analyzing participation in physical activity/rehabilitation [40] or classification in sport [37] among people with disabilities. Concerning Phase 1, regarding the selection of the key parameter, the proposal respected the ICF structure, including a checklist for each ICF category [34], responding appropriately in this study to deficits that people with ABI may present and the factors that could influence recovery [45]. On the other hand, the key parameters proposal presented to the experts was designed taking into account the most common ABI deficits (at physical, cognitive, sensory and socio-affective levels), addressing the functional heterogeneity of this population. In this way, the high results along the items' score assessment from the experts may come from the adequacy and usefulness of the ICF

as a theoretical framework, as a crossroad for multidisciplinary approach when dealing with exercise for ABI.

With regard to Phase 2, according to Alpha Cronbach results, the design of the ad hoc instrument, the referents “Relevance” and “Adequacy” made it possible to determine the importance of the items, and the possibility of adding qualitative information allows us to suppose the effectiveness of the instrument. The topics proposed by [64] collect all the useful aspects to assess the quality of the original proposal of this study. On the other hand, as discussed in previous studies, using a heterogeneous panel with experimental experts could be an appropriate way to achieve the goal [67,68].

“Phase 3” expressed in the design focused on assessing the proposal; the results of this study indicate the usefulness of the proposed tool. It should be noted that in the domain “Body Functions and Structures”, items were highly rated, with those items referring to the limitations of the joints, to avoid pain, to take into account hypersensitivity, and to check functionality of upper and lower limb. In our opinion, this fact is relevant, given the multidisciplinary profile of the experts’ panel and the importance of these items for exercise prescription [69–72]. It is also remarkable that the score regarding establishing the progression of intensity and duration of the exercise was the highest, which may indicate the importance of using exercise professionals for the design and implementation of exercise. In the domain “Activity and Participation”, the items refers to task design for the functional diversity, and the ratio to maintain quality was highly rated, which is possibly due to the heterogeneity of this population, which needs a great diversity of strategies and individualized plans [8,73]. Finally, the domain of “Environmental Factors” emphasized the item regarding the relationship with the multidisciplinary team and the family, which highlights the current neuro-rehabilitation model and the role of family in the recovery process [3,74].

The lack of studies similar to this work makes it difficult to evaluate this original proposal, although the selection of key parameters has been designed by experts in exercise and ABI [47], and endorsed by a panel of experts that cover all areas of neuro-rehabilitation [75]. One potential line for future studies could be the appropriateness of these results in relation with virtual/augmented reality exercise programs in ABI rehabilitation (XXXX). Also, in the future, comparisons between exercise programs for the ABI population based on these outcomes (or not) should be performed. Assessment of the (expected) cost–outcome ratio of a (given) program or between different exercise programs should also be studied. Moreover, the results, taking in consideration the experts profile opinion and experience, provide strong evidence that this research tool is efficiently detailed, structured, and appropriate for therapeutic approaches, as it meets the criteria of ABI professionals.

One limitation of the current study that needs to be considered in future research is related to the quantity of the ABI professionals who participated, also to develop test-retest to establish reliability of the measurement tool. However, each participant had experience in the field of ABI evaluation and treatment. One potential line for future studies could be the appropriateness of these results in relation with virtual/augmented reality exercise programs in ABI rehabilitation [76]. Therefore, future research needs to focus on creating a functional assessment tool to derivate people with ABI to the most beneficial exercise according to the goals of the multidisciplinary team, functional capacity, and personal characteristics.

5. Conclusions

This study demonstrated the adequacy of the key parameters based on the ICF to design and implement exercise for people with ABI. The findings presented here suggest that more interrelation is needed between areas of neuro-rehabilitation and exercise professionals to achieve high functional recovery and HRQoL in subacute and chronic phase with people with ABI. Further investigation is required to establish a clinical guide to prescribe exercise for people with ABI, and to serve as a basis for the exercise professionals.

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