Application of Single Subject Experimental Designs in Adapted Physical Activity Research: A Descriptive Analysis

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Abstract—The purpose of this study was to develop a descriptive profile of the adapted physical activity research using single subject experimental designs. All research articles using single subject experimental designs published in the journal of Adapted Physical Activity Quarterly from 1984 to 2013 were employed as the data source. Each of the articles was coded in a subcategory of seven categories: (a) the size of sample; (b) the age of participants; (c) the type of disabilities; (d) the type of data analysis; (e) the type of designs, (f) the independent variable, and (g) the dependent variable. Frequencies, percentages, and trend inspection were used to analyze the data and develop a profile. The profile developed characterizes a small portion of research articles used single subject designs, in which most researchers used a small sample size, recruited children as subjects, emphasized learning and behavior impairments, selected visual inspection with descriptive statistics, preferred a multiple baseline design, focused on effects of therapy, inclusion, and strategy, and measured desired behaviors more often, with a decreasing trend over years.

Keywords—Adapted physical activity research, single subject experimental designs.

I. INTRODUCTION

SINGLE subject experimental designs, which are also named as single subject time series design or single-case research designs, are research designs employing periodic measurements on individual subjects over a number of conditions [1] to determine the effect of an independent variable. At least two types of conditions are included in a single subject design, a baseline condition and an intervention condition. A baseline condition is first established to find the stability of the dependent variable without intervention and a treatment condition is then introduced to see the change of the dependent variable caused by intervention. These two conditions are repeated in different ways in different types of single subject designs so that a causal relationship between the intervention of using a treatment and the changes of measurements on the dependent variable(s) can be confidently established [2].

In the employment of a single subject experimental design,

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the subject serves as his/her own control, rather than using another individual or group, through the repeatedly introduction of baseline and intervention conditions on the same subject. This implies that the use of a single subject is good enough to evaluate the effect of an intervention in single subject designs. There may more than one subject (e.g., a group of 10 subjects) in a study using single-subject design; however. This type of study is still a single-subject design research if these subjects serves as their own control as described before [3]. Single subject experimental designs have been used extensively in applied research of psychology, education, and human behavior to evaluate the effect of a variety of interventions [4], [5].

The extensive employment of single subject experimental designs in applied research is primarily resulted from two problems frequently encountered by researchers that make the research studies difficult. First, due to the vast spectrum of the different categories and levels of disabilities, it is imperative that programs or interventions be individual in nature, that is, different independent and dependent variables be chosen for different subjects depending on the skills and require change [6]. Every program should be designed to meet the unique needs of a subject. This makes it is almost impossible to conduct a group program instruction or employ a group experimental design. Second, individuals with a type of disability may have a low incidence and are widely dispersed in communities. This makes a large group of subjects is difficult to be recruited for research [7], [8], which again makes the group experimental designs almost unfeasible.

Adapted physical activity research, which has been focusing on physical activities for people with disabilities, has been facing similar problems in conducting individualization and recruiting subjects. Single subject experimental designs have been used in the field of adapted physical activity research since 1984. Many researchers in this filed have chosen to use single subject experimental designs in the research. A single subject design, ABAB time series, was employed to evaluate the effects of an individual contingency system in decreasing inappropriate behaviors for students with disabilities in adapted physical education classes [9], for example, while another type of single subject design, multiple baseline across skills, was used to determine the effects of a progressive time delay strategy on teaching motor skills to adults with severe mental retardation [10].

As a matter of fact, the increase of research using single subject experimental designs has been found over the past 37

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years based on AAHPERD research abstracts in the field of adapted physical activity research [11]. In a total of 562 abstracts retrieved under special populations published by AAHPERD conventions from 1968 to 2004, 38 research abstracts employed single subject experimental designs with an increasing trend over years 1968-2004 (Y = - 0.0061 + 0.0032X, F[1,35] = 11.63; = p <. 05) have been found. This reveals that researchers in adapted physical activity have shown more interest in the use of single subject experimental designs over years; many questions about application of these single subject designs in adapted physical activity research, however, have not been answered in this study [11] and in the literature [4].

How many AAHPERD research abstracts using single subject designs were expended into whole research articles published in Adapted Physical Activity Quarterly (APAQ)? What type of the sample size were APAQ articles using single subject designs employed? Did these APAQ articles recruited children and adults as the participants? What types of disabilities did APAQ articles using single subject designs focus on in their research? What types of single subject designs, what types of independent variables, what types of dependent variables, and what type of statistics were those APAQ articles preferred? An investigation is needed to find a descriptive profile to answers to these questions. Therefore, the purpose of this study was to develop a descriptive profile of APAQ research articles using single subject designs.

II. METHOD

A. Data Source

All research articles using single subject experimental designs published in the journal of Adapted Physical Activity Quarterly from 1984 to 2013 were employed as the data source of this study. APAQ is the major research journal in adapted physical activity, first initiated in 1984 and then published quarterly. It is internationally recognized in the professional field of adapted physical activity.

B. Data Collection

Two individuals, one was a graduate student in adapted physical activity, and another was a professor in adapted physical activity, manually searched for all research articles using single subject experimental designs published in each of the 120 APAQ issues published from 1984 to 2013. All articles searched were then coded by these two individuals separately based on the categories of analysis and their subcategories presented below.

C. Dada Coding

All articles searched were coded based on a subcategory defined in each of the seven categories. Categories refer to those descriptive phrases developed from analyzing contents of documents [12]. Based on the features and format of research articles identified and the textbooks, Single subject research: applications in educational and clinical settings and Single Subject Research in Special Education, a total of seven categories were used in this study: (a) the size of sample; (b)

the age of participants; (c) the type of disabilities; (d) the type of data analysis; (e) the type of designs, (f) the independent variable, and (g) the dependent variable.

Subcategories are components of a category developed for coding the research articles [11]. The number of subcategories reflects the breadth of a category so that no relevant information is missed, that is, not coded. The subcategories were also designed to be mutually exclusive. Based on these rules and related knowledge in the literature, the coding subcategories used in this study are presented as follows.

The first category of analysis, the size of sample, including two coding subcategories: (a) small sample size or (b) large sample size. The small sample size is employed to code articles using less than 10 participants, while the large sample size codes articles using more than 10 participants and 10 participants.

The second category, the age of participants, consists of two coding subcategories: (a) children and (b) adults. The first subcategory refers to the participants whose age are less than 18 years old and the second subcategory refers to the participants whose age are older than 18 or equal to 18 years old.

The third category, the type of disabilities, has two coding subcategories: (a) learning and behavioral impairments and (b) physical and health impairments. The first subcategory is used when a research focuses on such disabilities as learning disabilities, behavior disorders, intellectual disabilities, autism, and emotional disturbance. The second subcategory is used when a research focuses on physical or health related disabilities (e.g., hearing impairments, orthopedic impairments, diabetes, and heart diseases).

The fourth category, the type of data analysis, includes two coding subcategories: (a) visual inspection with descriptive statistics or (b) visual inspection with inferential statistics. The first subcategory is employed when research contains such descriptive statistical data as frequency, percentage. The second subcategory codes such research as primarily using visual inspection with inferential statistics (e.g., Mann-Whitney U test and Friedman's two way analysis).

The fifth category, the type of designs, has three subcategories: (a) reversal design, (b) multiple baseline design, and (c) other single subject designs. The first subcategory refers to the research using designs such as AB or ABAB. The second one refers to the research using multiple baseline design across setting, across participants or time series. The third one refers to the research using other types of single subject designs that are not included in the first two subcategories (e.g. alternate treatment design).

The sixth category, the independent variable, includes five coding subcategories: (a) inclusion, (b) therapy, (c) strategy, (d) consequence, and (e) assistance. The first subcategory is used to code articles primarily focusing on the effect of an independent variable (e.g., peer tutoring) in inclusive settings. The second one is used to code articles focusing on the effect of a treatment variable (e.g., aerobic exercises) on controlling undesired behaviors. The third one is used to code articles focusing on the effect of an instructional procedure (e.g., the

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time delay) in teaching motor skills. The fourth one is used to code articles focusing on the effect of a consequence procedure (e.g., reinforcement) in physical activities. The last subcategory is used to code articles focusing on the effect of an antecedent procedure (e.g., demonstration) in training activities.

The seventh category, the dependent variable, includes three coding subcategories: (a) desired behaviors, (b) undesired behaviors, and (c) compound behaviors. The first one is used to code articles primarily measuring the desired behaviors (e.g., motor performance) resulted from the implementation of an independent variable. The second one code articles measuring the undesired behaviors (e.g., disruptive behaviors) resulted from the use of an independent variable. The third one code articles measuring both the desired behaviors and the undesired behaviors resulted from the use of an independent variable.

The author uses the above subcategories as criteria to code each article retrieved. An individual research article is assigned only one subcategory of a designated category, because all coding subcategories are mutually excluded. Each research article is coded six times, once for each category. For example, an article dealing with the effect of relaxation training on the motor performance of children with learning disabilities and hyperactive behaviors [13] is coded in the subcategories of small sample, children, learning and behavioral disabilities, multiple baseline design, visual inspection with descriptive statistics, and therapy program.

D. Data Analyses

All research articles retrieved were coded using a coding sheet. This sheet was used for coding the subcategories of the six categories. The first author coded all research articles retrieved. The coauthor coded all retrieved articles again separately. The coded data by two authors were analyzed to determine an estimate of an interrater agreement coefficient. This reliability coefficient is calculated with the agreement method (i.e. the number of agreement divided by the number of agreement plus disagreement and then multiplied by 100).

The second form of data analysis was descriptive statistics, including frequencies and percentage. Two types of frequencies were obtained in this study. The first type of frequency was the summed number of research articles published on APAQ from 1984 to 2013. Another type was the summed number of research articles using single subject designs retrieved from APAQ issues from 1984 to 2013. With these frequencies, a percentage of the summed number of articles using single subject designs in the summed number of research articles published on APAQ from 1984 to 2013 was then found.

A total of six percentages were computed by the summed number of articles coded as in a given subcategory across the year 1984-2013 been divided by the total articles coded and then multiply by 100. A summed number of articles coded as in a given subcategory refereed to a frequency of research articles using single subject designs coded in a given subcategory in a category. The total articles coded were the summed number of articles with single subject designs published on APAQ from 1984 to 2013. A percentage obtained was used to indicate the proportion of a subcategory in its category across the years 1984-2013.

The last form of data analysis was to estimate a trend of research articles using single subject designs published on APAQ over years 1984-2013. The time period of 1984-2013 was divided into six phases, including 1984-1988, 1989-1993, 1994-1998, 1999-2003, 2004-2008, and 2009-2013. The summed number of articles with single subject designs in each of the six phases was then counted. Based on these numbers in each of these phases, a trend of research articles using single subject experimental designs published on APAQ over years 1984-2013 could be visually inspected.

III. RESULTS

A mean of the interrater reliability coefficient of 96% was found for the identification of research articles using single subject experimental designs between two authors. About the interrater reliability for coding all retrieved articles into each subcategory in each category, a mean coefficient of 93% was found. This 93% was averaged, as presented in Table I, from six percentages in six categories.

TABLE I
AGREEMENTS, DISAGREEMENTS, AND RELIABILITY COEFFICIENTS IN THE SEVEN CATEGORIES OF ANALYSIS FOR COMPLETED RESEARCH ARTICLES USING SINGLE SUBJECT DESIGNS PUBLISHED ON APAQ BETWEEN 1984 AND 2013

Category	Agreement	Disagreement	Coefficient
The Size of Sample	27	0	100.00%
The Age of Participants	27	0	100.00%
The Type of Disabilities	27	0	100.00%
Type of Data Analysis	25	2	92.59%
The Type of Designs	24	3	88.88%
Independent Variable	23	4	85.18%
Dependent Variable	23	4	85.18%
Mean	---	--	93.12%

As presented in Table II, a total of 26 articles with single subject experimental designs were identified from a total of 540 research articles published on APAQ issues between 1984 and 2013. This reveals that among APAQ research articles published over years 1984-2013, about 4.81% of these articles employed single subject experimental designs.

As presented in Table III, most articles retrieved used the small sample size (92.59%), focused on children (66.66%) with learning/behavioral impairments (85.19%), and used the visual inspection with descriptive statistics (81.48%) in their data analyses. Almost a half of the articles retrieved selected the multiple baseline single subject design (44.44%) to control external threats. Top three independent variables among these articles were therapy treatment (29.63%), inclusion research (22.22%), and teaching procedure (22.22%). The majority of all retrieved articles focused on measuring desired behaviors (77.77%).

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TABLE II
THE PROPORTION OF COMPLETED RESEARCH ARTICLES USING SINGLE SUBJECT DESIGNS IN RESEARCH ARTICLES PUBLISHED ON APAQ BETWEEN 1984 AND 2013

Total Articles with SSED (A)	Total Research Articles (B)	% of A in B
27	661	4.08

TABLE III
DESCRIPTIVE STATISTICS OF THE 19 CODING SUBCATEGORIES IN THE SEVEN CATEGORIES OF ANALYSIS FOR COMPLETED RESEARCH ARTICLES USING SINGLE SUBJECT DESIGNS PUBLISHED ON APAQ BETWEEN 1984 AND 2013

Category bn Subcategory	Descriptive Statistics f	%
The Size of Sample		
Small Sample Size (< 10)	25	92.59
Large Sample Size (≥ 10)	2	7.41
The Age of Participants		
Children (< 18 years old)	18	66.66
Adults (≥ 18 years old)	9	33.34
The Type of Disabilities		
Learning/Behaviors Impairment	23	85.19
Physical/Health Impairment	4	14.81
The Type of Data Analysis		
Visual Inspection/Descriptive Statistics	22	81.48
Visual Inspection/Inferred Statistics	5	18.52
The Type of Designs		
Multiple Baseline Design	12	44.44
Basic Reversal Design	8	29.63
Other Designs	7	25.93
The Independent Variable		
Therapy Treatment	8	29.63
Inclusion Research	6	22.22
Teaching Procedure	6	22.22
Consequence Study	5	18.52
Antecedent Research	2	7.41
The Dependent Variable		
Desired Behaviors	21	77.77
Undesired Behaviors	2	7.41
Compound Behaviors	4	14.81

As shown in Table IV, a decreasing trend of the research articles using single subject experimental designs was found over years 1984-2013. During the first 20 years, the research articles using single subject designs has decreased from 7 in 1984-1988, 6 in 1989-1993, 4 in 1994-1998, to 3 in 1999-2003. This trend stabilized on 3 articles in 2004-2008 and increased to 4 articles in 2009-2013.

TABLE IV
THE NUMBER OF RESEARCH ARTICLES USING SINGLE SUBJECT DESIGNS PUBLISHED ON APAQ BETWEEN 1984 AND 2013

Phase	I	II	III	IV	V	VI
Articles	7	6	4	3	3	4

Note. I = 1984-1988, II = 1989-1993, III = 1994-1998, IV = 1999-2003, V = 2004-2008, and VI = 2009-2013.

IV. DISCUSSION

The interrater reliability coefficients obtained in this study indicated that the research articles using single subject designs were consistently retrieved and coded by the two authors. The results obtained in this study are thus reliable for describing an overall profile of adapted physical activity research with single subject experimental designs. This profile characterizes at least ten features as presented below.

First, single subject experimental designs have been used in a small portion of adapted physical activity research. As presented in Table II, only 4.81% of the APAQ research articles employed single subject experimental designs to evaluate the effect of independent variables. This result is similar to the result found by Zhang and his colleagues [11]. Among the total adapted physical activity research abstracts published by AAHPERD over years 1968-2004, a small portion of abstracts using single subject experimental designs, 6.76%, was obtained in the total research abstracts. The adapted physical activity research has used such designs as group experimental designs, Ex Post Facto designs, and descriptive designs more often than single subject experimental designs.

Second, most research articles using single subject experimental designs have taken a small sample size. As presented in Table III, 92.31% of the APAQ articles using single subject designs recruited less than 10 subjects in their research activities. A total of 6 school children, for example, were recruited as subjects in the study of evaluating the effects of untrained and trained peer tutors on the motor performance of students with developmental disabilities in an inclusive physical education setting [14]. The use of a small sample size in these research articles reflects the basic feature of single subject designs with which just one or several subjects are needed for controlling threats to validity.

Third, most research articles using single subject experimental designs have employed children as subjects in research activities. As shown in Table III, more than a half of the APAQ articles using single subject designs, 65.38%, recruited subjects with an age less than 18 years old. This implies that single subject research designs have been applied in the school settings more than the community settings. In the study completed by Yang and her colleague [15], for example, a total of 6 school-aged students with a mean age of 17 years old were employed as subjects to evaluate the effects of a four-step teaching strategy on motor skill performances, including basketball free throw, overhand softball throw, and dart throw performances.

Fourth, most research articles using single subject experimental designs have focused on learning and behavior impairments. As presented in Table III, 88.46% of the APAQ articles using single subject designs used subjects with learning and behavior impairments in research activities. Included in learning and behavior impairments were such disabilities as intellectual disabilities, autism, emotional disorders, learning disabilities, and attention deficits disorders. The primary reason why this finding was obtained is that single subject experimental designs have been employed as basis research design in applied behavior analysis while individuals with learning and behavior impairments often have behavior issues to be handled.

Fifth, most research articles using single subject experimental designs have employed visual inspection with descriptive statistics in the data analysis. As shown in Table III, 80.77% of the APAQ articles using single subject designs used a visual inspection approach plus such descriptive

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statistics as frequency and percentage in analyzing and graph the data they found. This might be resulted from that the application of inferred statistics to single-subject designs has been controversial. In the use of single-subject research designs, an individual or a group of several individuals are recruited as subjects and each subject served his or her own control, which make results being difficultly generalized using inferred statistics [16].

Sixth, most research articles using single subject experimental designs have employed a multiple baseline design in their research activities. In the use a multiple-baseline design, an adapted physical activity research systematically varied one of the three parameters (behavior, subject, or setting) while keeping the other two parameters constant. This design involved the careful measurement of multiple behaviors, subjects, or settings both before and after the use of a treatment, in which treatment conditions was started at different times across subjects so that changes resulted from the treatment could be concluded [17]. It might be why adapted physical activity researcher used a multiple baseline design more often than a reversal design which only measured a single subject.

Seventh, most research articles using single subject experimental designs have focused on effects of therapy, inclusion, and strategy. As presented in Table III, 26.92% of the APAQ articles using single subject designs focused on therapy, 23.60% on inclusion, and 23.60% on strategy. For example, [13] had a focus on the effect of relaxation exercises on behaviors using a reversal design; [14] had a focus on the effects of peer tutors in an inclusive physical education setting using a multiple baseline design; and [10] had a focus on a progressive time delay procedure on teaching motor skills using a multiple baseline design.

Eighth, most research articles using single subject experimental designs have focused on measuring desired behaviors. As presented in Table III, 76.92% of the APAQ articles using single subject designs focused on desired behaviors. For example, [13] employed a self-regulation instructional strategy for facilitating sustained cycling behaviors to three students with severe autism; [18], [19] used a constant time delay procedure for facilitating lifetime sport skill performance to 4 adolescents with severe to profound intellectual disabilities; and [20] used peer tutoring for facilitating social interaction behaviors between elementary school age students with severe and multiple disabilities and peers without disabilities.

Finally, all research articles using single subject experimental designs retrieved have demonstrated a decreasing trend over years. As presented in Table IV, the number of research articles using single subject experimental designs in each phase has gradually decreases over years, from 7 in 1984-1988, 6 in 1989-1993, 4 in 1994-1998, 3 in 1999-2003, 3 in 2004-2008 to 3 in 2009-2013. This finding is contrary to the finding found by [13]. Among the total adapted physical activity research abstracts published by AAHPERD over years 1968-2004, an increasing trend was found in a regression equation, ($Y = -0.0061 + 0.0032X$, $F[1,35] =$ 11.63; $= p <. 05$), over years. Reasons why this contrary exists is valuable to be investigated further.

In conclusion, a descriptive profile of the APAQ research articles using single subject designs is developed in this study. This profile tells us that among APAQ research articles, a small portion of articles used single subjects designs, in which most researchers used a small sample size, recruited children as subjects, emphasized learning and behavior impairments, selected visual inspection with descriptive statistics in the data analysis, preferred a multiple baseline design, focused on effects of therapy, inclusion, and strategy, and measured desired behaviors more often, with a decreasing trend over years 1984-2013.

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