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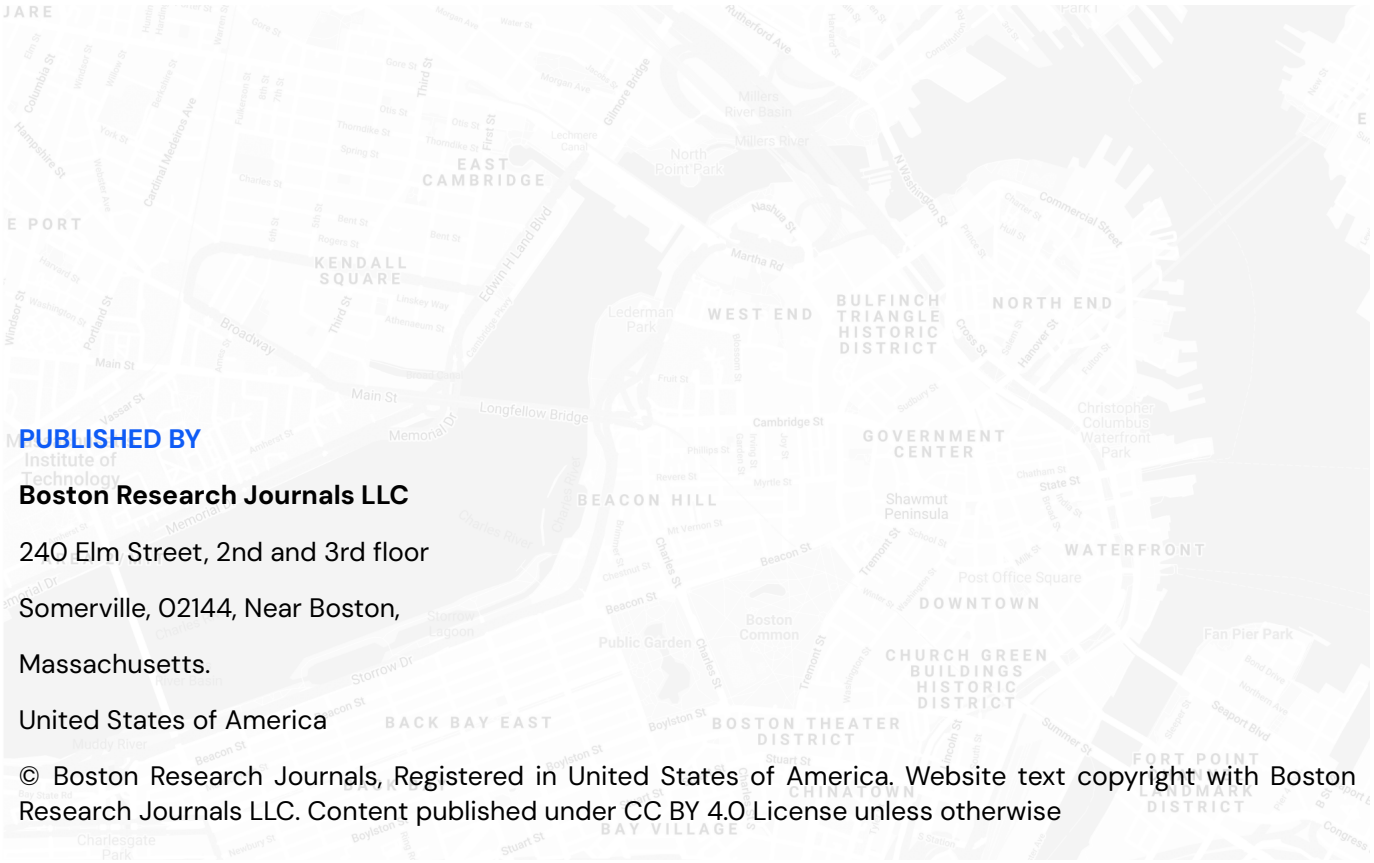

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Preface

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Validity and Reliability of the KORR Metabolic System During Submaximal and Maximal Exercise

Craig E. Broeder[δ], Anton Simms[θ], Aiste Petraityte[ε], Alexander H.K. Montoye[ρ]

ABSTRACT

This study compared the KORR CardioCoach Pro metabolic system to the COSMED clinical-research system during submaximal steady-state exercise and maximal aerobic capacity. Eighteen adults (50.3 ± 11.9 yrs old, 78.6 ± 10.6 kg, 25.6 ± 8.0 % body fat, and cardiovascular fitness rank equalled 83rd percentile) completed the validation phase, while nine subjects were randomly assigned to the test-retest phase. Metabolic data were collected simultaneously with both systems. VO2 max (mls • kg • min-1) was not significantly different between systems (COSMED = 40.3 ± 5.7; KORR = 41.5 ± 5.8; ES = 0.21). There were no between-system differences for max ventilation, tidal volume, respiration rate, carbon dioxide production, or respiratory exchange ratio. The intra-class correlation (ICC) and regression slope between the two systems showed excellent agreement (ICC: 0.95; r-squared = 0.94; p = 0.0001; SEE = 1.4 mls • kg-1 • min-1). During submaximal exercise, no statistical differences between systems were observed. The intra-class correlation (ICC) and regression slope between the two systems showed excellent agreement (ICC: 0.92; r-squared = 0.937; p = 0.0001; SEE = 0.058 mls • kg-1 • min-1). These results indicate the KORR metabolic system accurately measured metabolism during both submaximal and maximal cycling.

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Author: ***δ*** **–** PhD. FACSM, FNAASO

I. INTRODUCTION

Over the last several years, more affordable metabolic testing systems have been used to monitor a person's fitness and wellness programming outcomes (Montoye et al., 2020; Tsekouras et al., 2019). These systems simplify the calibration and setup process, so testing is easily performed in fitness, wellness, and nutritional centres. In the past, assessments of resting metabolic rate, maximal oxygen uptake, and metabolic efficiency were done in either university-based research or medical centre labs.

With advances in technology, newer systems may provide cost-effective and accessible testing options for general fitness/wellness clients wanting to improve cardio-respiratory capacity (i.e., VO2 max), energy efficiency profiles (fat versus carbohydrate use at rest and/or exercise), or understanding metabolic needs during exercise at various training zones. Additionally, these systems, through post-testing data processes, are focused on helping practitioners customise a client's fitness and preventive health goals while at the same time easily evaluating the client's real-time progress for personalised adjustments, i.e., improvement in fitness leading to changes in a person's training zone targets (Capostagno et al., 2021). From a health perspective, individuals interested in losing weight or improving body composition, metabolic testing may help fitness/health experts provide a more individualized exercise and dietary intake program that fine tunes the balance between macronutrient intake, dietary composition, and the person's energy expenditure patterns like current trends in personalized medical treatments (Abul-Husn & Kenny, 2019; Braig, 2022; Goetz & Schork, 2018). Finally, maximal oxygen uptake testing provides clients with important information about their current cardiovascular disease risk based on their maximal metabolic equivalent level achieved (METS) at the time of testing. Previous research shows that maximal oxygen uptake values are strong predictors of premature cardiovascular events and death (Ross et al., 2016; Swainson et al., 2019). Correspondingly, previous exercise behavioural research suggests that providing individuals real-time health and physical activity information may be a powerful positive motivator of current and future health behaviours (Ferguson et al., 2022; Singh et al., 2022). However, it is equally important that the use of this information comes via accurate and reliable testing so that the information is properly actionable for the client (Shei et al., 2022).

While metabolic testing can provide valuable fitness and health information, the data collected is only valuable if the metabolic system and process are accurate and reliable. We previously showed that when compared to standardized research-based oxygen uptake testing results, initially, affordable metabolic testing systems in fitness clubs produced very inconsistent results (Broeder, 2014). However, more recent research with affordable metabolic systems suggests that when testing follows proper population-specific protocols (Tsekouras et al., 2019) and proper graded exercise testing guideline procedures (ACSM, 2021), newer systems can provide accurate and reliable data. Additionally, other lower-cost systems specifically designed to measure resting metabolic rate have also been shown to be reliable and valid (Nieman et al., 2006; Nieman et al., 2005; Vandarakis et al., 2013).

This study, in a healthy active adult population, compared the KORR CardioCoach Pro metabolic system to a previously validated medical research system (Nieman et al., 2013) developed by the COSMED corporation (Chicago, IL) during submaximal steady-state exercise and for maximal aerobic capacity determination. The COSMED comparison system was recently used in a similar metabolic system comparison study (Tsekouras et al., 2019). Although the KORR metabolic systems are currently used in many fitness centres, weight loss facilities, and even universities, there has not been an independent external CardioCoach Pro study conducted comparing this system to a research-grade validated device.

II. METHODS

Participants

Subject participation was conducted following the ethical principles stated in the Declaration of Helsinki (World Medical, 2013), which includes ethics approval obtained before initiating the study, consent forms taking into consideration the well-being, free will, and respect of the participants, and respect of privacy. Prior to starting the study, all study protocol items were approved by Pearl IRB, which is an independent, accredited Institutional Review Board by the Association for the Accreditation of Human Research Protection Programs. This research was carried out in accordance with the ethical standards of the International Journal of Exercise Science (Navalta et al., 2019). Each subject completed the study's consent form and a medical and physical activity history form. If a subject met all inclusion criteria, they then received a trial-testing schedule.

To participate in the study, all subjects were classified as low risk for coronary artery disease according to the American College of Sports Medicine (ACSM) Graded Exercise Testing guidelines between 18 and 65 years of age (ACSM,

2021). Subjects were required to be currently active (exercise 3-5 times per week on a regular basis over the 6-months prior to starting the study). All subjects were free of metabolic disease (e.g., diabetes), acute infection (e.g., flu), COVID-19, chronic inflammatory conditions (e.g., rheumatoid arthritis), lung disease (e.g., COPD or restrictive lung), and were currently not taking medications to treat hypertension. Pregnant females were excluded from the study. Because initial subject screening items included bioelectric impedance body composition assessment, individuals with implanted electronic devices were excluded from participating in the study. Subjects were recruited from the local area population. Twenty-one subjects volunteered to participate in the study. Of those, 18 subjects (9 females; 9 males) completed the validation portion of the study. Two subjects did not complete the study due to schedule changes (i.e., lack of time), and one subject did not meet all pre-screening criteria. Ten subjects were randomly selected to participate in the test-retest reliability aspect of the study. One subject did not complete this portion of the study due to a schedule change and lack of time, leaving nine for the reliability analysis.

III. PROTOCOL

Body composition was assessed using InBody's 570 multi-frequency bioelectrical impedance (BIA) system (InBody, Cerritos, CA). Each subject was instructed to abstain from solid food for 4 hours prior to testing. Subjects were instructed to drink 12-16 oz of water two hours before testing to ensure proper hydration status as recommended by the manufacturer. If testing took place in the morning, subjects did not strenuously exercise the evening prior. For afternoon or evening testing, subjects did not perform any strenuous exercise the day of testing.

Maximal aerobic capacity was determined using a standardised linear ramp cycling protocol with 3-minute stages, hereafter referred to as the VO2 max test. The starting workload was 75 watts (Stage 1). With each subsequent stage, the workload increased by 25 watts every 3 minutes until each subject reached volitional fatigue. All testing was performed using a Tacx Smart Bike system, which was controlled by an ANT+ ergometer mode computer system. The Tacx Bike (Garmin, USA) testing protocol was controlled using a computer program designed by Rouvy (Czech Republic) that automatically adjusts the force required based on a subject's individual cadence pattern (i.e., low versus high cadence subject), target power independent of a person's preferred cadence.

Submaximal workload determinations were established using the VO2 max protocol data results. The submaximal workloads consisted of three 6-minute stages set at 60%, 75%, and 90% of each person's max watts achieved during the VO2 max test. Maximal watts were determined using a weighted mean that included the last stage a cyclist completed and the fraction of the next stage up to the final end point (e.g., Stage 7–225 W at 180s and Stage 8–250 W at 30s = 229 W at VO2 max). As with the VO2 max test, submaximal workloads were programmed and controlled through the Rouvy cycling software as described above.

Exercise testing trial data were collected each day using identical testing set-up procedures and methods. Testing occurred at the same time of the day ± 30 minutes across all submaximal and maximal trials to avoid diurnal effects on metabolic rate. Subjects were asked to avoid strenuous exercise 24 hours prior to testing and maintain the same dietary intake pattern on the days prior to and the day of testing. These procedures allowed us to minimise the effects that diet and exercise can have on metabolic measurements 18-24 hours prior to exercise measurements (Broeder et al., 1991). Prior to starting the specific trial protocol for a given day, each subject completed a 20-minute standardised cycle ergometer warm-up based on their respective fitness.

The two metabolic systems (COSMED and KORR) were calibrated as recommended by each manufacturer just prior to the start of each subject's trial. The COSMED system calibrations required the flow sensor and gas sensors to use a semi-automated process to accurately measure volume, O2, and CO2 values during the trials based on known calibration volume (3-litre syringe X 6 full breath simulations) and a gas standard calibration process using O2 = 16% & CO2 = 4% concentrations. In contrast, the KORR system uses a totally automated calibration process. The flow sensor was pre-calibrated at the factory, and the gas sensors were pre-calibrated at the factory and then automatically pre-test calibrated using a room-air sensor zeroing process for both the flow and gas sensors. Once the calibration process was completed, the metabolic collection masks for both

systems were secured on each person as shown in Figure 1. Next, each subject sat on the cycle ergometer at rest for 2-3 minutes to ensure metabolic variables stabilised prior to starting the exercise protocol. Heart rate, ventilation, tidal volume, respiratory rate, watts, oxygen consumption (VO2), carbon dioxide production (VCO2), and respiratory exchange ratio (RER; VCO2/VO2) data were continuously recorded on both systems simultaneously for each stage during both the submaximal and maximal exercise trials.

Figure 1 - Mask Set-Up For Simultaneous Data Collection on Both Systems

For the submaximal exercise trials, based on previous pilot data, the mean of minutes 4-6 (steady-state values) was used at each respective workload for the between (validity data) and within (reliability) system comparisons. For the maximal oxygen uptake trials, VO2 max was defined as achieving the following three criteria: a plateau in oxygen uptake (≤ 1-2 ml/kg) with increasing workloads, RER ≥ 1.05, and a maximal heart rate ± 5 beats/minute of each subject's age-predicted maximal heart rate (Tanaka et al., 2001).

IV. STATISTICAL ANALYSIS

Data are presented as mean ± standard deviation (SD) in all tables and within the Results section. All summary figures are presented as the mean ± SEM. For maximal effort data, metabolic and pulmonary data were analysed using t-test procedures. Submaximal data were analysed using two-way repeated-measures ANOVA. Tukey's post-hoc procedures were used to determine where statistical differences occurred (i.e., VO2 at 60% vs. 75% of max). For the test-retest comparisons, a repeated measures ANOVA model was used to compare within and between systems at each respective submaximal measurement period. Cohen's d effect size (ES) procedures were used to determine the magnitude of the difference for each respective comparison when appropriate. Cohen's d measures the difference between two means divided by the pooled standard deviation of each mean. The effect size descriptors used were very small = 0.01, small = 0.20, medium = 0.50, large = 0.80, large = 1.20, and very large = 2.0. In addition, to compare the two systems, intra-class correlation and regression analyses, Bland-Altman plots with bias and limits of agreement (LOA) analyses were performed. A power analysis was performed to find a significant correlation coefficient between systems, ranging from 0.80 to 0.95, p-value = 0.05, power value (1-ß) = 80%, and sample size = 16 subjects. Finally, the data were analysed using Prism 9.4.1.

V. RESULTS

Subject and fitness performance characteristics (Tables 1 & 2) are presented for all subjects and compared to a randomly assigned test-retest subject group. There were no statistical differences observed in physical or performance-related characteristics between the groups.

Table 1 - Subject Physical Characteristics

Characteristic	All Subjects (m=9; f=9) Mean ± SD	Test-Retest (m= 4; f=5) Subjects	Between Group P-value
Age	50.3 ± 11.9	50.7 ± 11.3	NS
Height (meters)	1.72 ± 0.08	1.70± 0.07	NS
Body Weight (kg)	78.6 ± 10.6	78.6 ± 8.5	NS
BMI (Wt/Ht^2)	26.7 ± 3.12	27.3 ± 3.14	NS
Body Fat (%)	25.6 ± 8.0	26.5 ± 8.7	NS
Lean Body Mass (kg)	58.6 ± 10.0	57.7 ± 7.5	NS
Skeletal Muscle Mass (kg)	32.8 ± 6.0	32.3 ± 4.40	NS

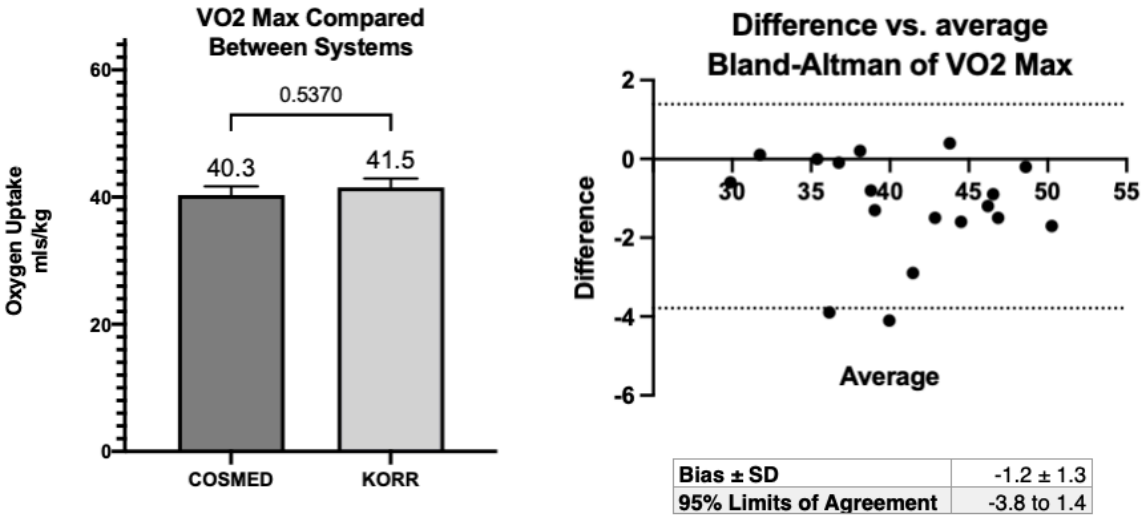
Table 2 - Baseline Fitness Performance Characteristics

Characteristic	All Subjects (m=9; f=9) Mean ± SD	Test-Retest (m= 4; f=5) Subjects	Between Group P-value
Ve max (liters • min^{-1})	117.0 ± 25.9	113.0 ± 25.6	NS
VO_2 max (mls•kg^{-1}•min^{-1})	40.3 ± 5.7	38.9 ± 5.7	NS
VO_2 max (liters • min^{-1})	3.150 ± 0.528	3.031 ± 0.361	NS
VCO2 max (liters • min^{-1})	3.345 ± 0.535	3.240 ± 0.405	NS
RER (VCO_2/VO_2)	1.07 ± 0.03	1.07 ± 0.10	NS
Max Watts Achieved	224 ± 44	207 ± 35.2	NS

Maximal exercise comparisons (Figures 2) between systems showed there were no significant differences in oxygen uptake for all subjects combined (COSMED = 40.3 ± 5.7; KORR = 41.5 ± 5.8; ES = 0.21) The intra-class correlation (ICC) and regression slope between the two systems showed excellent agreement (ICC: 0.95; r-squared = 0.94; p = 0.0001; SEE = 1.4 mls • kg-1 • min-1).

The Bland-Altman analysis showed a Bias ± SD equaled -1.2 to 1.3 with a 95% LOA = to -3.8 to 1.4. Furthermore, there were no significant differences observed between the systems for maximal ventilation in liters • minute-1, tidal volume in liters • minute-1, maximal respiratory rate in breaths • minute-1, and VO2 max & VCO2 max in liters • minute-1, or RER values (Figure 3).

Figure 2 - Maximal Oxygen Uptake (mls · kg^{-1}) Comparisons Between Systems



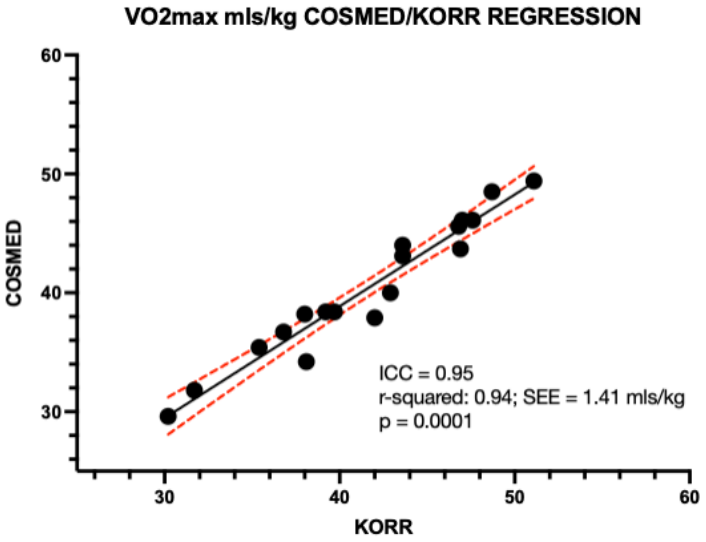
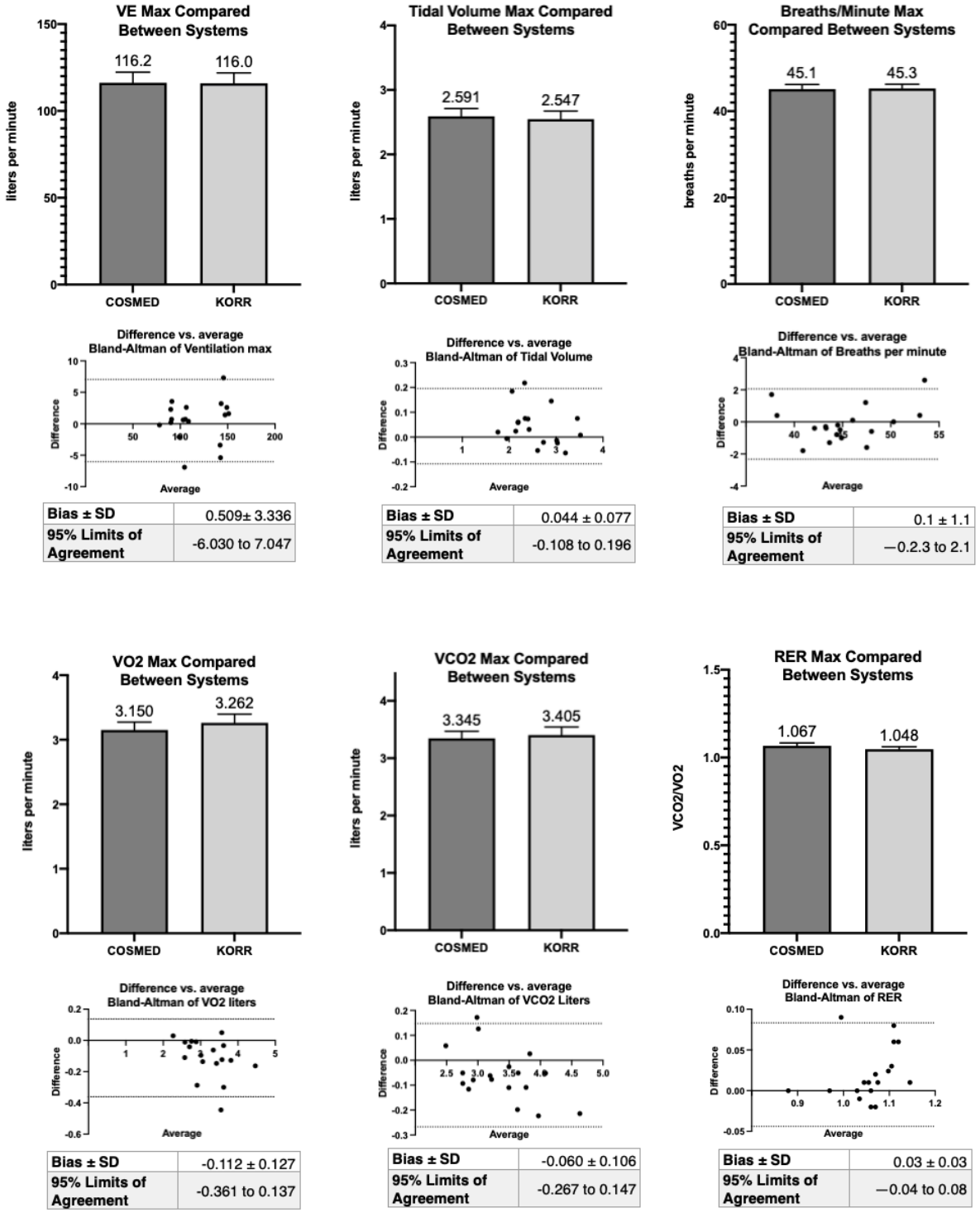
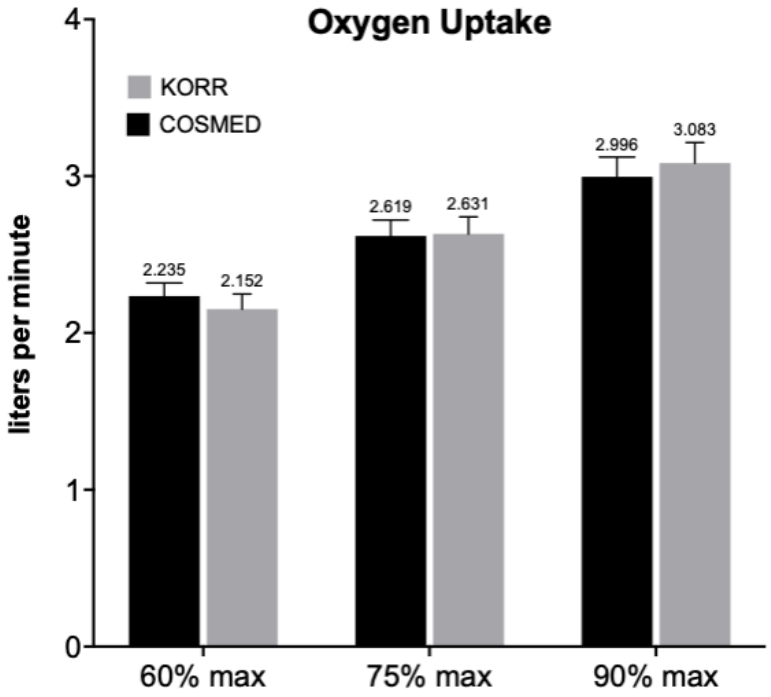


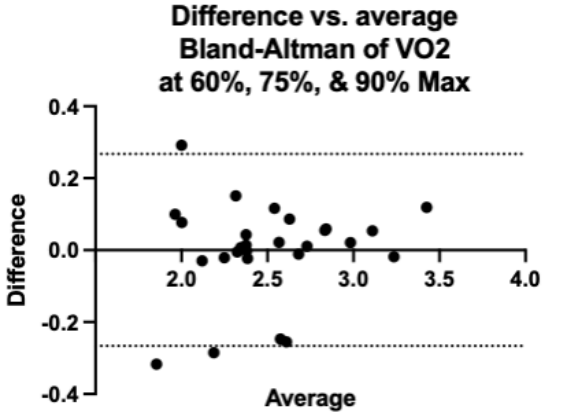
Figure 3 - Maximal Pulmonary and Oxygen Uptake System Comparisons



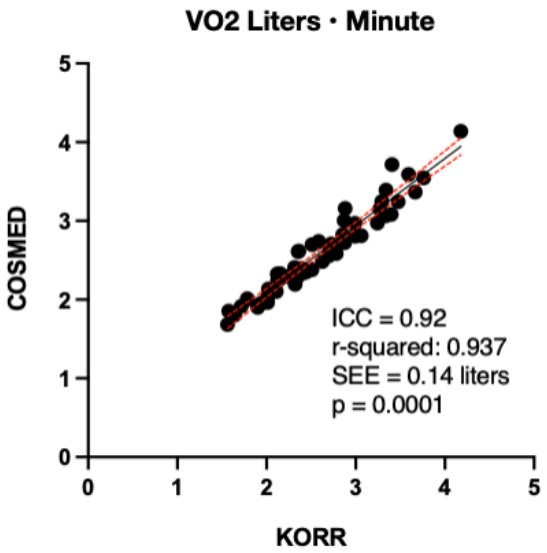
Submaximal exercise comparisons (Figure 4) between system comparisons showed there were no significant differences observed in oxygen uptake in litres per minute. The intra-class correlation (ICC) and regression slope between the two systems showed excellent agreement (ICC: 0.92; r-squared = 0.937; p = 0.0001; SEE = 0.058 mls • kg-1 • min-1). The Bland-Altman analysis showed a Bias ± SD equal to 0.00 to 0.14 with a 95% LOA = to - .27 to 0.27.

Figure 4 - Submaximal Oxygen Uptake (liters • min-1) Between System Comparison





Bias ± SD	0.00 ± 0.14
95% Limits of Agreement	-0.27 to 0.27



Submaximal test-retest results (Table 3) within and between each of the system comparisons showed no significant differences observed at any of the three exercise workloads for VO2 in mls • kg-1 • or liters • min-1, VCO2 in liters • min-1, or RER values. Using the overall submaximal test day VO2 (mls • kg-1 • min-1) mean of each trial and system, the within-system mean difference during submaximal effort day 1 versus 2 was 2.5% and 1.9% for the COSMED and KORR systems, respectively. For VCO2 (litres • min-1), the within-system difference was 0.3% (COSMED) and 1.9% (KORR), while RER (VCO2/VO2) was 1.0% (COSMED) and 0.3% (KORR).

Table 3 - Sub-maximal Metabolic Data Within and Between System Comparisons

Percent of VO2 Max Watts Achieved @ Baseline †	COSMED System		KORR System		Significance Between Days Within Each System	Significance Between Systems Across Days Tested
	Day 1	Day 2	Day 1	Day 2		
	VO2 (mls^{-1} • kg^{-1} • min^{-1})					
60% max	27.3 ± 3.3	26.4 ± 4.0	27.4 ± 2.2	26.3 ± 3.1	NS	NS
75% max	32.0 ± 3.1	32.4 ± 4.0	32.0 ± 2.9	32.3 ± 3.6	NS	NS
90% max	35.4 ± 5.5	38.2 ± 5.0	36.7 ± 3.7	38.2 ± 4.7	NS	NS
	VO2 (liters • min^{-1})					
60% max	2.137 ± 0.208	2.071 ± 0.340	2.150 ± 0.221	2.067 ± 0.297	NS	NS
75% max	2.505 ± 0.224	2.539 ± 0.377	2.508 ± 0.275	2.536 ± 0.353	NS	NS
90% max	2.873 ± 0.307	3.000 ± 0.444	2.858 ± 0.365	2.997 ± 0.428	NS	NS
	VCO2 (liters • min^{-1})					
60% max	1.946 ± 0.252	1.886 ± 0.365	1.973 ± 0.247	1.931 ± 0.337	NS	NS
75% max	2.423 ± 0.256	2.437 ± 0.388	2.433 ± 0.340	2.477 ± 0.432	NS	NS
90% max	2.955 ± 0.370	3.024 ± 0.484	2.933 ± 0.477	3.070 ± 0.583	NS	NS
	RER (VCO2/VO2)					
60% max	0.91 ± 0.06	0.91 ± 0.06	0.92 ± 0.05	0.93 ± 0.05	NS	NS
75% max	0.97 ± 0.06	0.96 ± 0.05	0.97 ± 0.05	0.97 ± 0.05	NS	NS
90% max	1.03 ± 0.06	1.00 ± 0.05	1.02 ± 0.06	1.02 ± 0.06	NS	NS

† (60% of max watts = 131 ± 24 watts; 75% of max watts = 164 ± 30 watts; 90% of max watts = 195 ± 36 watts)

VI. DISCUSSION

This study's purpose was to compare the reliability and validity of the KORR metabolic system compared to a previously validated metabolic system, the COSMED Quark medical research system. The Quark metabolic cart was previously compared to the Douglas Bag Gold Standard method (Nieman et al., 2013). Nieman et al. (Nieman et al., 2013) determined that the Quark metabolic system measured values for ventilation and VO2 were in excellent agreement with the Douglas Bag method at submaximal and maximal effort exercise (Ventilation: r-square = 0.94, mean differences ± 11.1 mls • min-1; Oxygen Uptake: r-square = 0.97, mean differences ± 2.3 mls • kg-1 • min-1). In addition, the mean absolute oxygen uptake difference for all measurements (submaximal and maximal efforts) was 0.8% (COSMED: 2.754 ± 1.193; Douglas Bag Method: 2.731 ± 1.195 mls • min-1).

In the current study, there was excellent agreement between the COSMED and KORR metabolic testing systems during both steady-state submaximal and maximal exercise efforts. Interestingly, while the COSMED system is a breath-by-breath system and KORR uses a mini-mixing chamber (not breath-by-breath) design, our results were similar to a previous study comparing the PNOE breath-by-breath system with the same COSMED system used in the current study (Tsekouras et al., 2019). Tsekouras et al. (2019)

reported that for VO2 (ml • min-1), the mean percent difference across all stages combined was 1.5% (COSMED: 2.217 ± 0.605; PNOE: 2.183 ± 0.604 litres • min-1). In the current study, looking at the VO2 (liters • min-1) comparison between systems, the difference was 0.0% (COSMED: 2.750 ± 0.409; KORR: 2.750 ± 0.477 litres • min-1). For VCO2 (mls • min-1), the reported PNOE to the COSMED system percent mean difference was 2.6% (COSMED: 2.209 ± 0.738; PNOE: 2.152 ± 0.741 litres • min-1). The KORR percent mean difference in VCO2 was 0.1% (COSMED: 2.736 ± 0.583; KORR: 2.740 ± 0.645 litres • min-1). For ventilation, the PNOE versus COSMED was 1.4% (COSMED: 55.6 ± 17.5; PNOE: 54.8 ± 17.0 litres • min-1), while the KORR system was 0.6% (COSMED: 87.5 ± 25.9; KORR: 87.0 ± 26.2 litres • min-1). Finally, PNOE measured RER percent difference compared to COSMED was 1.2% (COSMED: 0.98 ± 0.07; PNOE: 0.97 ± 0.08), while the KORR system was 0.0% (COSMED: 0.99 ± 0.07; KORR: 0.99 ± 0.07). Table 4 summarises the absolute mean % error values and the range across all stages measured in the PNOE and the current study. Additionally, using data supplied by Montoye et al. (Montoye et al., 2020), a similar comparison in Table 4 included their study, which compared the PARVO versus the VO2 Master portable metabolic system

Table 4 - Absolute % Difference§ and Range Between Systems Compared Across All

Measurement	PNOE Reported Mean % Error (Range) Compared To COSMED System	KORR Reported Mean % Error (Range) Compared To COSMED System	VO2 Master¥ Reported Mean % Error (Range) Compared To PARVO Med System
Ve (liters • min^{-1})	1.4% (0.2% - 2.3%)	0.6% (0.2-% - 2.1%)	1.6% (0.7% - 5.8%)
VO2 (liters • min^{-1})	1.6% (1.2% - 2.5%)†	0.01% (0.0% - 3.8%)	6.4% (1.5% - 16.8%)
VCO2 (liters • min^{-1})	2.6% (1.9% - 5.6%)	0.1% (0.3% - 4.0%)	NA
RER or RQ	1.2% (0.4% - 3.3%)†	0.0% (0.3% - 2.3%)	NA

† We found a small report error in the original article for VO2 values (2) . Thus, the absolute error values are slightly different than would have occurred from original article's data. The data error correction we report actually improves the PNOE VO2 comparison with the COSMED Quark system. Accordingly, the reported RQ values are also slightly changed as a result.

¥ = The VO2 master system only measures ventilation and VO_2 (1).

§ Between system differences were calculated using the following equation: Absolute Difference (Reference System-Test System)/Mean (Reference System + Test System)

In the current study, there were no significant differences observed in determining VO2 max between the systems for all subjects combined and when comparing the test-retest group (Figures 2 & 3). Additionally, Table 3 highlights that both the COSMED and KORR systems had excellent test-retest agreement within and between the systems. For example, if one looks closely at the VO2 (litres • min-1) results, one can see that for each stage, both systems pick up each stage's subtle day-1 to day-2 differences. To illustrate, at 60%, both systems showed oxygen uptake was slightly higher on day 1 versus day 2. For 75% of the max, day 1 and day 2 are virtually the same in both systems. And for the final submaximal effort state at 90% of max, the day 1 data were slightly lower than day 2 in both systems.

These findings are important because systems must be able to correctly detect small, moderate, and large changes accurately. For example, in the HERITAGE Family Study (Bouchard et al., 1999), the authors found that after 20-weeks of standardised supervised aerobic training, the mean oxygen uptake increase was approximately 400 mls for 481 subjects tested pre-to-post.

However, the study also showed that there was extensive adaptation heterogeneity across individuals, with some losing or having only very small changes in VO2 max over time, and others gaining in excess of 1 litre • minute-1 in VO2 max. Thus, given the individual heterogeneity and the relatively small mean changes in fitness likely even over long-duration interventions, it is necessary for metabolic systems to be able to detect relatively small differences over time.

The primary purposes of many newer metabolic systems are to monitor a person's fitness and wellness programming outcomes over time by using a simplified and less expensive testing process. Therefore, it is critical that such systems can detect similar subtle changes consistently and accurately that occurred in the current study. For example, a recent study published by Montoye at al. (2020), comparing the VO2 Master portable metabolic system versus the Parvomedics 2400 (criterion) system, showed that the VO2 Master device had a mean VO2 percent error for submaximal and maximal exercise ranging from 0.8 to 5.8%. However, regression analysis of the VO2 max data in litres • minute-1 between both systems showed there was minimal agreement between the systems (r-squared = 0.17, SEE = 0.302, p = NS). In contrast, the same analysis comparing the KORR to COSMED systems showed excellent agreement (r-squared = 0.94, SEE = 1.41, p = 0.0001) and between the PNOE and COSMED system (Intraclass Correlation Coefficient = 0.98, Confidence Interval = 0.96 - 0.99, p = 0.0001). To further emphasise the importance of being able to collect reliable and valid metabolic data, if one considers the 302 mL SEE in the VO2 Master study in the context of the training changes observed in the Heritage Family Study, approximately 175 of 481 total subjects were tested in this study (36% of the study population), and improved ≤ 300 mls. Thus, the VO2 Master system may not be able to consistently detect such small changes in VO2 max, while both the PNOE and KORR systems appear accurate enough to determine these changes.

In conclusion, this study's results show that the KORR metabolic system data were both reliable and valid compared to the COSMED Quark system when strict research testing guidelines and protocols were used. At the same time, the authors believe that manufacturers of these newer devices should provide clear and detailed testing guidelines and training programs for testing personnel. No matter how accurate a metabolic system is, without proper protocol design and general testing procedures, achieving accurate client data may be compromised (Broeder, 2014).

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VIII. DATA AVAILABILITY

This study's data will be provided by the corresponding author as needed.

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RESEARCH ARTICLE BY BOSTON RESEARCH JOURNALS, UNITED STATES OF AMERICA

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Malocclusion, Oral Motor Function, and Food Selectivity in Autism Spectrum Disorder: A Narrative Review and Research for Orthodontic Care

Paulo Vinicius de Oliveira Bastos[δ], Adrielen Henrique Picoli[θ], Katia Rosiane Müller Lauxen[ε], Anna Gabriela da Silva Pierre[η], Marcio Trevisan Ribeiro[κ], Jessica Castro Costa[ψ]

ABSTRACT

Children with autism spectrum disorder (ASD) present, as separate and well-documented phenomena, both a higher prevalence and complexity of malocclusion and a markedly elevated rate of food selectivity linked to oral sensory hypersensitivity and oral motor difficulties. Despite the plausibility of a relationship between these two conditions, no study has yet examined whether orthodontic or dental treatment, as an outcome or as an intervention, is directly associated with food selectivity patterns in individuals with ASD. This narrative review synthesises three established but previously unconnected lines of evidence—malocclusion in ASD, food selectivity and oral sensory hypersensitivity in ASD, and oral motor function as a mechanistic link between them—drawn from international (PubMed/MEDLINE, PMC, ScienceDirect, ResearchGate) and Brazilian/Latin American (SciELO, PePSIC, LILACS) databases. We argue that this intersection constitutes a genuine gap in the literature and propose two specific research directions: (a) testing whether oral motor function and parafunctional habits associated with food selectivity predict the type and severity of malocclusion in children with ASD, and (b) evaluating how the introduction of fixed orthodontic appliances affects the already restricted dietary repertoire of these children, with attention to potential nutritional consequences. Addressing this gap would allow clinicians to design orthodontic protocols that are both effective and sensitive to the sensory and behavioural particularities of this population.

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Author(s): **δ –** Specialist in Family Health, Federal University of Rio de Janeiro (UFRJ), Specialist in Public Health, Master`s Degree in Orthodontics, Federal University of Juiz de Fora – RJ – Brazil.
θ - Specialist in Orthodontics, FAIPE. Cuiabá - MT - Brazil.
ε – Specialist in Orthodontics, Faculdade de tecnologia IPPEO – Porto Alegre – RS – Brazil.
η – Specialist in Pediatric Dentistry. Faculdade Sete Lagoas – Sete Lagoas – MG – Brazil.**κ –** Graduated in Dentistry, Universidade São Francisco – Bragança Paulista – SP – Brazil.
ψ – Specialist in Orthodontics, Universidade Cruzeiro do Sul – SP – Brazil.

I. INTRODUCTION

Autism spectrum disorder (ASD) is a neurodevelopmental condition characterised by persistent differences in social communication and interaction, alongside restricted and repetitive patterns of behaviour, which frequently include atypical sensory processing (American Psychiatric Association, 2013). Two clinical phenomena associated with ASD have been studied extensively, but almost always in isolation from one another: an elevated prevalence and complexity of malocclusion, and a strikingly high rate of food selectivity rooted in oral sensory hypersensitivity and oral motor difficulties. Both phenomena converge on the same anatomical structure—the oral cavity—and on overlapping underlying mechanisms, namely sensory processing atypicalities and oral motor function. Yet, to date, no published study appears to test whether orthodontic or dental treatment is directly associated with food selectivity patterns in children with ASD, either as a risk factor that treatment must accommodate or as an intervention that could plausibly influence dietary behaviour.

This narrative review had two purposes. The first was to map, across international and Latin American databases, the existing evidence connecting (a) malocclusion in ASD, (b) food selectivity and oral sensory hypersensitivity in ASD, and (c) oral motor function as a plausible mechanistic bridge between the two. The second was to make explicit the resulting gap in the literature and to propose a concrete research agenda for orthodontic and pediatric dental practice that takes food selectivity seriously as a clinically relevant variable.

II. METHODOLOGY

Searches were conducted in international databases (PubMed/MEDLINE, PMC, ScienceDirect, ResearchGate) and in Brazilian and Latin American databases (SciELO, PePSIC, LILACS, and institutional repositories), combining terms related to autism spectrum disorder, malocclusion, orthodontic treatment, food selectivity, and oral sensory processing. Because the aim was to characterise the state of the evidence and identify a specific gap rather than to exhaustively appraise study quality, we adopted a narrative, non-systematic review design, prioritising systematic reviews and meta-analyses where available and supplementing them with primary studies and descriptive clinical sources when higher-tier evidence was unavailable. Sources without identifiable individual authorship are cited in this review by article title, following APA style conventions for works without a named author.

Malocclusion in Children with Autism Spectrum Disorder

Several studies converge on the finding that children with ASD present a higher burden of malocclusion than their neurotypical peers. A comparison of 97 children (48 with ASD and 49 without) found a significantly higher Discrepancy Index score, a validated measure of malocclusion complexity, among children with ASD, an effect that persisted after adjusting for sex and age ("Malocclusion Complexity and Orthodontic Treatment Need," 2022). A systematic review and meta-analysis of malocclusion characteristics in ASD populations, drawing on PubMed, Scopus, Web of Science, Cochrane, Embase, and SciELO/LILACS, reached a similar conclusion and explicitly

recommended that future studies on malocclusion in ASD account for children's dietary and feeding history as a potential confounder ("Malocclusion Characteristics Amongst Individuals," 2022)—an early, if indirect, acknowledgment of the plausible link this review addresses directly. Occlusal traits in children with ASD have also been linked to parafunctional habits, oral motor function, and patterns of mastication and deglutition ("Prevalence of Malocclusion and Occlusal Traits," 2024).

In the Brazilian and Latin American literature, Campos Neto et al. (2025) examined the prevalence and types of malocclusion among pediatric and adolescent patients with ASD, while a literature review spanning PubMed/MEDLINE, SciELO, Google Scholar, and the Virtual Health Library (2009–2022) similarly described occlusal alterations in this population ("Alterações Oclusais em Pacientes com Transtorno do Espectro Autista," n.d.). A study on orthodontic treatment needs in children with ASD explicitly noted that malocclusion may worsen self-esteem, social interaction, and quality of life in this population, although this outcome was not measured empirically within the study itself ("Orthodontic Treatment Needs in Children with Autism Spectrum Disorder," 2025). Complementary integrative reviews on dental management in ASD, drawing on BIREME/BVS, SciELO, MEDLINE, PubMed, and LILACS, reinforce that behavioural and sensory particularities complicate both the diagnosis and the correction of occlusal problems in this population (Alves et al., n.d.; "Autismo Infantil e a Odontologia," 2021).

Food Selectivity and Oral Sensory Hypersensitivity in Autism Spectrum Disorder

A separate and substantial body of evidence documents that food selectivity is markedly more prevalent among children with ASD than among neurotypical children, with estimates ranging from roughly half to nearly nine in ten children affected ("Food Selectivity in Autism Spectrum Disorder," 2024). A scoping review of the interrelation between food selectivity, oral sensory sensitivity, and nutrient intake found that children with ASD are approximately five times more likely to develop feeding difficulties associated with selectivity, with oral sensory sensitivity to taste, smell, and texture playing a central role ("Interrelation of Food Selectivity, Oral Sensory Sensitivity, and Nutrient Intake," 2022).

Regional studies echo this pattern. A statistical analysis conducted in Southern Italy found correlations between food selectivity and sensory domains—particularly taste and smell—as well as between oral motor skills and food selectivity, using the Brief Autism Mealtime Behaviour Inventory alongside the Child Oral and Motor Proficiency Scale ("Food Selectivity in Children with Autism Spectrum Disorder," n.d.). A Chilean study of 57 children similarly found a strong association between oral, tactile, and socioemotional sensory hypersensitivity and food selectivity, with texture cited as a factor in 78% of cases and colour in 53% ("Food Pattern, Food Selectivity and Sensory Profile in Autism Spectrum Disorder," 2024/2025). A Malaysian study extended this line of evidence by associating oral sensory hypersensitivity with atypical mealtime behaviours and with overweight and obesity in children with ASD ("Weight Status and Associated Risk Factors of Mealtime Behaviours," 2022), underscoring that the consequences of food selectivity in this population extend beyond nutrition into broader metabolic health.

Some descriptive, non-quantitative sources in the dental literature have also noted, based on clinical observation rather than controlled study, that children with ASD tend to favour soft, sugar-rich foods because of food selectivity, which may in turn increase caries risk (Dentalclean, 2025). While this observation has not been tested quantitatively, it is clinically consistent with the sensory and behavioural evidence reviewed above and suggests that food selectivity may have downstream consequences for oral health that extend beyond occlusion.

Oral Motor Function as a Mechanistic Link

The two lines of evidence reviewed above—malocclusion and food selectivity—are not merely co-occurring; they appear to share a common mechanistic pathway in oral motor function. Difficulties in mastication, deglutition, and oral motor proficiency have been associated both with the development of malocclusion ("Prevalence of Malocclusion and Occlusal Traits," 2024) and, independently, with food selectivity itself ("Food Selectivity in Children with Autism Spectrum Disorder," n.d.). This convergence suggests that oral

motor function may function as an intermediate variable linking sensory processing atypicalities to both feeding behaviour and occlusal development, though this pathway has not been tested directly within a single study population.

The Unexplored Intersection: Orthodontic Treatment and Food Selectivity

Despite these two well-established, converging lines of evidence, our search across international and Latin American databases did not identify any study that directly examines the relationship between dental or orthodontic treatment and food selectivity in patients with ASD. This gap has two distinct dimensions that remain untested. First, it is unknown whether pre-existing food selectivity functions as a risk factor or a barrier to orthodontic treatment itself—for instance, through difficulty adapting to fixed appliances or through resistance to the inevitable changes in food texture that such appliances require during adjustment periods. Second, it is unknown whether the introduction of orthodontic treatment, by altering oral sensation, chewing mechanics, or comfort, could favourably or unfavourably influence a child's already restricted dietary repertoire. Reviews on the general management of dental patients with ASD (Alves et al., n.d.; "O Desafio do Atendimento Odontológico em Pacientes com Transtorno do Espectro Autista," 2024) and on orthodontists' perceptions of treating this population ("Transtorno do Espectro Autista no Atendimento Ortodôntico," 2026) discuss behavioural management challenges extensively but do not treat food selectivity as a correlated variable.

Proposed Research Agenda

Building on the gap identified above, we propose two concrete lines of investigation. The first would test whether oral motor function and the parafunctional habits associated with food selectivity in children with ASD predict the type and complexity of malocclusion they present, extending the confounder identified but not measured by prior systematic reviews ("Malocclusion Characteristics Amongst Individuals," 2022). The second would prospectively evaluate how the introduction of fixed orthodontic appliances affects the food repertoire of children with ASD who present pre-existing food selectivity, monitoring dietary intake and nutritional status in collaboration with a multidisciplinary team that includes speech-language pathology, nutrition, and occupational therapy. Both lines of research would benefit from standardised instruments already validated in the food selectivity literature, such as the Brief Autism Mealtime Behaviour Inventory and the Child Oral and Motor Proficiency Scale ("Food Selectivity in Children with Autism Spectrum Disorder," n.d.), applied alongside standard orthodontic indices such as the Discrepancy Index ("Malocclusion Complexity and Orthodontic Treatment Need," 2022).

Clinical and Multidisciplinary Implications

Even before dedicated studies close this gap, the evidence reviewed here has practical implications for clinicians. Orthodontists and pediatric dentists treating children with ASD should anticipate that existing food selectivity may complicate adaptation to fixed appliances and should proactively coordinate with caregivers and, where possible, with speech-language pathologists and nutritionists to monitor dietary intake during treatment. Conversely, clinicians should not assume that food selectivity is solely a behavioural issue to be managed at the chairside; it is a sensory and motor phenomenon with plausible bidirectional links to occlusal treatment that merits monitoring rather than incidental observation.

III. CONCLUSION

The literature confirms, as two separate and well-supported bodies of evidence, that children with ASD present greater malocclusion complexity than the general population and that food selectivity in ASD is strongly tied to oral sensory hypersensitivity and oral motor deficits. However, no identified study directly tests whether orthodontic treatment influences, for better or worse, food selection patterns, nor whether pre-existing food selectivity constitutes a risk factor or barrier to orthodontic treatment itself. This intersection represents a genuine and clinically meaningful opportunity for future research, one that would allow orthodontic care for children with ASD to be designed with explicit attention to its potential nutritional and behavioural consequences, in keeping with a broader, multidisciplinary, and humanised model of care for this population.

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Colour Therapy

Dr. Tinni Dutta[δ]

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Author(s): ***δ –*** Assistant Professor in the Department of Psychology, Muralidhar Girl's College, Kolkata.

I. INTRODUCTION

'Oh my fellow neighbours, open your doors, it is Holi. Holi has come to the land, water and forests. Open your doors, open your doors.'

The poet has summoned every neighbour of his to overcome all their barriers and obstacles, the hindrances which impede them from making merry, and immerse themselves in playing with colours.

Traditional treatment with colours was initiated by Carl Jung. The colours which rise from the innermost recesses of our inner world help in understanding the unique personality of an individual.

Playing with colours is the motto of the Indian festival of Holi. People of India, like the people of Egypt and China, have engaged themselves in colourful merry-making since ancient times. Making merry with colours has been seen from those times and is a part of their everyday lives, like flowers which bloom in the forest every day to give joy to the world.

Colour energy is stimulated by different parts of the body, such as the eyes and skin and are stimulated. To what extent colour treatment can be therapeutic is easily determinable.

Each experience of life, no matter how trivial, creates ripples in us. Some of the impacts are positive, but some are negative. Negativity has been found to bring about anxiety and bodily arousal. In such a case, the chakra affected can be located by the therapist, and treatment can be continued by increased exposure to the colour which fuels the energy of the chakra. For example, if the Kantha chakra is affected, the localisation in the body is of course the throat region. It is stimulated by the indigo colour. So by increased exposure to the indigo colour in varying shades, the client can be given colour therapy.

Colour treatment is a holistic treatment which is not age dependent. We are almost always surrounded by colours that are present in the earth and manifest themselves in a rainbow, which leads us to new dimensions of realisation and

understanding. Each colour has a different wavelength.

A humane and divine energy emanates from these colours. These relationships with colour and chakras are as follows: Violet–Crown; Indigo–Forehead; Blue–Throat; Green–Heart; Yellow–Solar; Orange–Sacral; Red–Root.

According to Carl Jung, colour is the key to the subconscious. They show the picture of the inner, private world. It evades the public eye and helps us make it beautiful, harmonious and joyful so that we are able to lead enriching lives. The sorrows, miseries, disappointments, despair and anger induced by daily hassles can all be done away with by resorting to appropriate colours. Happiness remains the primary motto in establishing a sense of being.

As yogic practice helps us alleviate mental and physical hurdles, the energy of colours elevates our consciousness.

Colour therapy and yoga are intrinsically linked with the concept of chakras, though not restricted with exclusivity to the seven chakras only.

Yoga and colour therapy together help to address emotions, thoughts and actions. It often serves as a cooling relaxation technique.

Colour therapy helps us to maintain the mind-body balance, enhancing physical energy, increasing circulation and blood flow to different organs of the body, stress reduction, expression of creativity, reduction of anxiety, increasing productivity, enhancing happiness by increased production of serotonin.

The administration of colour therapy, both diagnostic and prognostic, is quite simple in nature.

The rapport is established with the client initially. Then he/she is instructed to draw with his favourite colours. He might choose one, or he might choose many. Time constraint is not present. He can take his own time.

After completion of drawings, the picture is interpreted from a psycho-dynamical perspective. Chiefly, content and symbol analysis are done for assessing his personality patterns.

Psychotherapeutic intervention starts after completion of diagnosis. I am sharing a case study. For eg I.B., a teenage girl, was referred to me for her temper tantrums, aggression towards her mother, lack of concentration and deterioration in study. She was instructed to draw a picture with her favourite colours. She had drawn a home with black and red colours. She had come from a broken family; her father had departed from them long back. I suggested that her mother initiate a colour therapy session. It was implied from the diagnosis that she was suffering from severe depression coupled with a revolting attitude. It was evident from content and dynamic analysis and was corroborated with biographical findings. As she had used red and black colours, a revolting and depressive attitude toward life, to calm down and to restore inner balance, she was offered to draw pictures with green and blue colours, twice a week, and to come for psychotherapeutic sessions at least twice a month. She was also given other assignments, but it was not discussed here. Remarkable improvement was noticed. She became jovial and calm. She was told to continue follow-up. Now she had graduated from a reputed college and had regained her psycho-social balance.

Colour therapy rectifies and enhances secure attachment style. The instinctual responses mature at different times during the first year of life and develop at different rates; they serve the function of binding the child to mother and contribute to the reciprocal dynamic of binding mother to child (Bowlby, 1958).

Four stages of attachment theory are linked with colour therapy. Pre-attachment (newborn to 6 weeks). Attachments in Making (6 weeks to 6-8 months); clear-cut attachments (8 months to 24 months). Formation of reciprocal relationships 24 months & greater.

To resolve insecure attachment, clients may be instructed to use green, blue and yellow colours, at least for six weeks. It would yield good findings. Carl Ritberger set certain goals of colour therapy on an individual level. They are decreasing conflict, enhancing quality interpersonal relationships, increasing success and resourcefulness in the personal sphere, proper parenting, choosing the right career which gives wings to one's hidden potential, and learning the art of communicating effectively.

Hartman's colour code has helped in vocational selection and in promotion of life choices. It has psychometric properties like reliability and validity.

The concept of colour code personality by Dr. Taylor Hartman helps in profile Colour therapy. He has conceptualised the personality to be divided into four categories–Red lovers have a striving for power. Those who like blue value the depth and intimacy of interpersonal interactions. Yellow lovers are cheerful and amusement-loving by disposition and want to spend their lives in fun and frolic.

It was evident in earlier researchers like Pyfister that green and blue are indicative of sensitivity to both external and internal stimuli, suppressed impulsivity and show signs of ego-strength. Black implies depression at the unconscious level. In this case, the therapist would have to check on the use of black by the client.

So, to conclude, personality patterns could be assessed from the drawings. By analysing the pictures, the therapist could intervene by telling the client to avoid certain colours and utilise others, depending on his personality patterns. Thus, desirable changes could be elicited for removing sadness and enhancing happiness.

Drawing an allusion to Holi, we could utter, 'Today we have to add colour to everybody's palette. We have to be healthy; let's have that hope. The clouds are woven in colours; love lurks in the colour of the sun. Today the colour of light rings in the chirping of birds.'

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Influence of Electronic Information Resources on the Health Services Provision by Staff of Rev. Fr. Moses Orshio Adasu University Teaching Hospital, Makurdi

Pira-gbande, Jeffrey[δ], Ode, Elijah Ojowu[θ]

ABSTRACT

The study investigated the Influence of electronic information resources on health services provision by staff of Rev. Fr. Moses Orshio Adasu University Teaching Hospital, Makurdi. A research question was designed to find out the Influence of electronic information resources on health services provided by staff of Benue State University Teaching Hospital, Makurdi and a hypothesis was formulated and tested at a 0.05 level of significance. The study adopted the descriptive survey design. The population of the study consisted of 915 members of staff of the Benue State University Teaching Hospital, Makurdi. A sample size of 183 respondents was derived through multistage sampling techniques used for the study. Descriptive statistics of Mean and standard deviation were used to analyse the data. The result of the study revealed that electronic information resources have a significant influence on health services provided by staff of Fr.Fr. Moses Orshio Adasu University Teaching Hospital, Makurdi. Based on the findings, it was recommended that the management of Rev. Tr. Moses Orshio Adasu University Teaching Hospital should encourage the utilisation of electronic information resources for the provision of better health services through the provision of good infrastructure, such as the acquisition of databases for accessing electronic information resources.

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Author(s): **δ –** Department of Library and Information, Rev. Fr, Moses Orhio Adasu, University, Makurdi
θ – Department of Library and Information, Rev. Fr, Moses Orhio Adasu, University, Makurdi

I. INTRODUCTION

Health service provision is healthcare delivery services to individuals or communities by health workers in order to improve the health status of the people. It is a wide range of activities involving health care professionals in services that include, but are not limited to, diagnostic services, outpatient care services, laboratory, medication and treatment, among others, to the community they serve. Information is a key to the well-being of humanity and stands as the major determinant of decision-making. It could be equated to other economic resources such as capital and labour, in which an increased investment leads to enhanced productivity. Okiki (2017) posited that information is the pivot on which the survival of any society rests. Nowadays, information can be accessed through a range of information and communication technology tools. Information and communication technology has transformed all human activities dependent on information, particularly in the area of poverty reduction, healthcare delivery and education. It has made a significant impact on teaching and learning in higher education and has improved the flow of information to academic communities. It has changed the philosophy of information from unitary to global access. The technological advancement has availed librarians the options of handling varied information sources conveniently and effortlessly.

Electronic information resources are information materials requiring computer access using desktops or handheld mobile devices such as iPads, laptops, and smartphones in the library or at home for the purpose of teaching, studying and/or research. Electronic Information Resources include databases (online and offline), E-books, E-journals, E-newspapers, E-research reports and E-lecture notes. Others are e-theses/dissertation, e-indexes and e-abstracts, e-reference databases such as bibliographies, dictionaries as well as sounds and files (International Federation of Library Associations and Institutions (IFLA, 2015). They consist of information resources provided in electronic formats such as the internet, CD-ROM databases, e-books, e-journals, online databases, Online Public Access Catalogues, and other computer–based electronic networks. Electronic information resources are now a major resource in every university library, and they have significantly transformed information handling and management in academic environments and in University libraries in particular (Obaseki, 2015).

II. BASIC CONCEPTS

Electronic Information Resources: Electronic information resources are materials in digital format accessible electronically . Examples of e-resources are electronic journals (e-journal), electronic books (e-book), online databases in varied digital formats, Adobe Acrobat documents (pdf), web pages (html, asp) and so on.

Health Services: As used in this study, health services mean all kinds of care services rendered to sick people within a hospital environment by health care workers.

Teaching Hospitals: A teaching hospital is a medical centre that provides medical, educational and training to future and current health professionals. Teaching hospitals are almost always affiliated with one or more universities and are often co-located with medical schools. Teaching hospitals use a residency program to educate qualified physicians, podiatrists, dentists and pharmacists who are receiving training after attaining the degree of MD, DPM, DDS, DMD, PharmD, among others. The purpose of these residency programs is to create an environment where new doctors can learn to practice medicine in a safe setting that is supervised by physicians who provide both oversight and education.

Research Questions

What is the influence of electronic information resources on health services provided by staff of Rev. FR. Moses Orshio Adasu University Teaching Hospital, Makurdi?

III. HYPOTHESES

Electronic information resources have no significant influence on health services provided by staff of Rev. FR. Moses Orshio Adasu University Teaching Hospital, Makurdi. Literature Review

The term “health care services” means any services provided by a health care professional, or by any individual working under the supervision of a health care professional, that relate to (A) the diagnosis, prevention, or treatment of any human disease or impairment; or (B) the assessment or care of the health of human beings (Adamu&Olaide,

2018). Health services refer to the patient care provided by medical professionals, health care personnel, and health care organisations (Anyanwu& Benson, 2016). Health services consist of medical professionals, organisations, and ancillary health care workers who provide medical care to those in need. Health services serve patients, families, communities, and populations. They cover emergency, preventive, rehabilitative, long-term, hospital, diagnostic, primary, palliative, and home care. These services are centred around making health care accessible, high quality, and patient-centred. Many different types of care and providers are necessary in order to offer successful health services.

The provision of health services is also the answer to the question of the kind of society we want in the future. The fundamental principle is the determination of needs according to specified aims and the meeting of these needs. However, not everyone who is in need can use health services. The use of health services is related to the ability to pay the cost of the service, willingness to pay, how long it takes to reach the health centre, and culture (WHO 35). This explains why health services should not be focused on demand, but should be provided according to need (Starfield 17). However, the situation in which Nigerian society has found itself in recent years is the co-modification of the health service in Turkey and the provision of demand-oriented services, in line with worldwide trends. In Turkey, this situation has become even clearer over the last ten years. It is possible to summarise the situation by looking at some data.

The provision of health services had been taken out of the hands of physicians and transferred to the clergy. In those times, the treatment fees were too high for the poor to pay. The majority of people could not afford medical treatment because of their poverty. In this period, when diseases were thought to be caused by an imbalance in the organism, the provision of health services was patient-centred, and gaining the trust of the patient was fundamental. In places where there were no trained surgeons, barbers undertook this work. In the Middle Ages, scholastic medicine continued to play a role in increasing the strength of the church until the Renaissance. Books on medicine were translated into Arabic from the 7th to the 9th centuries. Using this knowledge, Islamic medicine made great contributions to the development of medicine (Ten, 2015). While Europe experienced bigotry in the Middle Ages, Islamic medicine developed with Ali Bin Abbas, Ibn Sina, Ebubekir Razi, Zahravi and Biruni. Placing importance on cleanliness in the prevention of disease, they looked after their patients in hospitals, which they called Darüşşifa, Bimaristan or Maristan. The plans of the hospitals founded in Europe after the Enlightenment were based on these hospitals. In this era, medical education in the West was in harmony with religious teachings. Trained physicians practised medicine according to the wishes of the clergy. For this reason, the practices of trained physicians were not always rational. The fact that physicians worked in the towns and palaces meant that those who lived outside the towns received their health services from people who had gained their medical knowledge through experience (Ten, 2015).

The influence of electronic information resources on the provision of health services is about information being able to affect user's purpose as needed, when needed, and where needed to enhance users' activity. The objective of influence is to enable users to derive benefit from electronic resources. Chandrasekhar (2016) observed that the influence of electronic information resources depends on the extent of usage of electronic resources as well as the demand for their use. Moreover, for effective provision of health services, it is important that the possible electronic resources be accessed and utilised by health care providers to ensure effective and efficient health care service delivery.

IV. METHODOLOGY

The study adopted a descriptive survey design to investigate the Influence of electronic information resources on health services provision by staff of Rev. FR. Moses Orshio Adasu University Teaching Hospital, Makurdi. A research question was designed to find out the Influence of electronic information resources on health services provided by staff of Rev. FR. Moses Orshio Adasu University Teaching Hospital, Makurdi and a hypothesis was formulated and tested at a 0.05 level of significance. The population of the study consisted of 915 members of staff of the Rev.Fr.Moses Orshio Adasu University Teaching Hospital, Makurdi. A sample size of 183 respondents was derived through multistage sampling techniques and was

used for the study. Descriptive statistics of Mean and standard deviation were used to analyse the data. The result of the study revealed that electronic information resources have a significant influence on health services provided by staff of Rev.Fr.Moses Orshio Adasu University Teaching Hospital, Makurdi. Based on the findings, it was recommended that the management of Benue State University Teaching Hospital should encourage the utilisation of electronic information resources for the provision of better health services through the provision of good infrastructure, such as the acquisition of databases for accessing electronic information resources.

V. DATA ANALYSIS

Research Question: What is the influence of electronic information resources on the health services provided by staff of Rev. FR. Moses Orshio Adasu University Teaching Hospital, Makurdi?

Table 1: Mean and Standard Deviation of the influence of electronic information resources on health services provided by staff of Rev. FR. Moses Orshio Adasu University Teaching Hospital, Makurdi

	S/N Item			N Mean Std.D	Decision
11	Surgical services	166	3.06	1.06	Agree
12	Patient care services	166	2.66	0.95	Agree
13	Dental services	166	3.01	0.89	Agree
14	Optical services	166	2.77	0.98	Agree
15	Diagnostic services	166	3.84	0.84	Agree
16	Laboratory services	166	2.87	1.00	Agree
17	Endoscopic services	166	3.28	0.87	Agree
18	Chemotherapy services	166	2.75	0.99	Agree
19	Echocardiography services	166	3.22	0.80	Agree
20	Physiotherapy services	166	2.78	0.96	Agree
	Cluster Mean	166	3.02		Agree

Source: Field Survey (2025).

The table above revealed that mean and standard deviation scores of 3.06 (1.06), 2.66 (0.95), 3.01 (0.89), 2.77 (0.98), 3.84 (0.84), 2.87 (1.00), 3.28 (0.87), 2.75 (0.99), 3.22 (0.80), 2.78 (0.96), and clusters of 3.02 (0.94) were above the 2.50 mean cut-off point. This result showed that staff of Benue State University Teaching Hospital provide the following services: Surgical services, Patient care services, Dental services, Optical Services, Diagnostic services, Laboratory Services, Endoscopic Services, Chemotherapy Services, Echocardiography Services and Physiotherapy Services. The cluster mean of 3.02 and standard deviation of 0.94 implied that the respondents agreed that the above health services are provided by staff in Benue State University Teaching Hospital, Makurdi.

VI. DISCUSSION OF THE FINDINGS

The findings of the study revealed that electronic information resources have a significant influence on health services provided by staff of

Benue State University Teaching Hospital, Makurdi. This finding is in line with the findings of Ndeso (2016), who investigated the influence of electronic information resources on the provision of medical services at MOI Teaching and Referral Hospital and found that electronic information resources have a strong influence on the provision of health services at MOI Teaching Hospital. The finding also agrees with the findings of Maharana (2019), who found that medical institutions, particularly in developed countries, have invested heavily in Information and Communication Technologies (ICT), not only to deliver quality of services that health professionals provide but also to make shared health information available for speedy treatment. From the study, the researcher observed that the use of the internet and electronic information resources is increasing rapidly and is a useful component for the delivery of quality health services for patient care and evidence-based medicine. This has been observed among staff of Benue State University Teaching Hospital, as the use of electronic information resources has ultimately enhanced their work and productivity. This is because electronic resources mostly influence the provision of health services in health institutions where there are facilities and infrastructure, as well as awareness of their usage, more than in places where such infrastructure that determines their usage is lacking.

Also, the research found that all the respondents were using the electronic information resources frequently because the management of the hospital had provided connection to the Internet; and both clinical and laboratory staff were getting quality information through the Internet. 88% of respondents search for diagnosis information through the Internet because the teaching hospital has provided access to various medical e-databases for all staff. They use the Internet in different ways, such as accessing online journals, downloading software or text, chatting, discussion, e-mail services and finding related documented cases. The analysis reveals that 72.2% of electronic information resource users always find useful information on the Internet. 42% of respondents believed that electronic information resources provide quality information that is instrumental in quality health care delivery.

VII. RECOMMENDATIONS

Based on the findings of the study, the following recommendations were made: The management of Rev. FR. Moses Orshio Adasu University Teaching Hospital, Makurdi, should sustain the provision of existing electronic information resources for accessibility and utilisation among members of staff.

There should be encouragement of utilisation of electronic information resources for provision of better health services through provision of good infrastructural facilities like new computers, free internet services and acquisition of databases for accessing electronic resources. The management of Rev. FR. Moses Orshio Adasu University Teaching Hospital, Makurdi, should make infrastructure available suitable for utilisation of electronic information resources such as: good and regular power supply, good computers, internet, training and retraining of staff for computer literacy skills.

Health service providers should endeavour to use electronic resources like MEDline, HINARI, BIOMED, Heliographies and e-medical journals for quality health service provision. The management of Benue State University Teaching Hospital Makurdi should ensure that there are available electronic databases, modern computers, and regular power supply, a speedy and adequate Local Area Network within the university teaching hospital for effective utilisation of electronic information resources

When all these recommendations are put into cognisance, there could be effective and efficient provision of health services delivery in Benue State University Teaching Hospital, Makurdi.

VIII. CONCLUSION

Based on the results of the study, it was concluded that electronic information resources have a significant influence on the provision of health services in Rev. FR. Moses Orshio Adasu University Teaching Hospital, Makurdi. This is because there is high awareness and utilisation of electronic information resources among staff of Benue State University Teaching Hospital, Makurdi

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