TABLE OF CONTENTS

Dedication

Declaration

Certificate

Acknowledgements

Urkund Analysis Result

Abstract

List of Tables i

List of Figures v

Chapter 1

INTRODUCTION

1.1 OVERVIEW 1

1.1.1 ANTHROPOMETRY 3

1.2 LITERATURE REVIEW 7

1.2.1 STUDIES DONE ON THE ASSESSMENT OF NUTRITIONAL STATUS AMONG CHILDREN 8

1.2.2 STUDIES DONE ON THE ASSESSMENT OF NUTRITIONAL STATUS AMONG ADOLESCENTS 11

1.2.3 STUDIES DONE ON THE ASSESSMENT OF NUTRITIONAL STATUS AMONG ADULTS 15

1.2.3.1 Undernutrition 16

1.2.3.2 Overweight and obesity 19

1.2.3.3 Determinants of overweight/obesity 24

1.2.3.4 Other Complementary Indices 26

1.2.3.5 Body composition 29

1.2.4 INDIAN STUDIES DONE ON THE ASSESSMENT OF NUTRITIONAL STATUS AMONG ADULTS 31

1.2.5 STUDIES DONE ON THE ASSESSMENT OF NUTRITIONAL STATUS AMONG ADULTS OF NORTHEAST INDIA 42

1.2.6 STUDIES IN THE DIFFERENT FIELDS OF BIOLOGICAL ANTHROPOLOGY, INCLUDING NUTRITION AMONG ADULTS FROM SIKKIM 46

1.3 OBJECTIVES OF THE PRESENT STUDY 47

Chapter 2

MATERIALS AND METHODS

2.1 THE POPULATION 48
2.1.1 THE LIMBOO 52
2.2 THE AREA 59
2.3 NATURE OF SAMPLING AND SAMPLE SIZE 67
2.4 PROCEDURES OF DATA COLLECTION 68
2.4.1 DEMOGRAPHIC, SOCIO-ECONOMIC AND LIFE STYLE FACTORS 68
2.4.1.1 Demographic variables 69
2.4.1.2 Socio-economic variables 70
2.4.1.3 Life style variables 73
2.5 ANTHROPOMETRIC MEASUREMENTS 74
2.5.1 PROCEDURES OF TAKING MEASUREMENTS 74
2.5.1.1 Height 75
2.5.1.2 Weight 76
2.5.1.3 Sitting height (SH) 76
2.5.1.4 MUAC 76
2.5.1.5 Neck circumference (NC) 77
2.5.1.6 Waist Circumference (WC) 77
2.5.1.7 Hip Circumference (HC) 77
2.5.1.8 Arm span 78
2.5.1.9 Arm length 78
2.5.1.10 Biceps Skinfold (BSF) 78
2.5.1.11 Tricep skinfold (TSF) 79
2.5.1.12 Sub-scapular Skinfold (SSF) 79
2.5.1.13 Suprailiac Skinfold (SISF) 79
2.5.2 TECHNICAL ERROR OF MEASUREMENT 79
2.5.3 ASSESSMENT OF NUTRITIONAL STATUS 81
2.5.3.1 Body Mass Index (BMI) 82
2.5.3.2 Mid Upper arm circumference (MUAC) 83
2.5.3.3 Waist Circumference (WC) 83
2.5.3.4 Waist-Hip Ratio (WHR) 84
2.5.3.5 Waist-Height Ratio (WHtR) 84

2.5.3.6 Cormic Index (CRI) 85
2.5.3.7 Conicity index (CI) 85
2.5.3.8 Neck Circumference (NC) 85
2.5.3.9 Body Adiposity Index (BAI) 86
2.5.4 ASSESSMENT OF BODY COMPOSITION 86
2.5.4.1 Upper Arm Composition 86
2.5.4.2 Body Density (BD) Assessment 87
2.5.4.3 Assessment of Percentage Body Fat (PBF) 87
2.5.4.4 Assessment of Fat mass (FM) and Fat free mass (FFM) 88
2.5.4.5 Assessment of Fat mass index (FMI) and Fat free mass index (FFMI) 88
2.5.4.6 Assessment of status of body fatness 89
2.5.4.7 Assessment of related risk factor with PBF 89
2.6 STATISTICAL ANALYSIS 90

Chapter 3

RESULTS

3.1 DISTRIBUTION OF DEMOGRAPHIC, SOCIO-ECONOMIC, AND LIFE STYLE RELATED VARIABLES AMONG THE LIMBOO INDIVIDUALS 94
3.1.1 POPULATION SIZE AND STRUCTURE 94
3.1.2 MARITAL STATUS 95
3.1.3 EDUCATION 96
3.1.4 OCCUPATION 97
3.1.5 FAMILY MONTHLY INCOME 98
3.1.6 SOCIO-ECONOMIC STATUS (SES) 100
3.1.7 FAMILY SIZE 101
3.1.8 LAND HOLDING PATTERN 102
3.1.9 HOUSE TYPE 103
3.1.10 DRINKING WATER 104
3.1.11 TOILET 105
3.2 ASSESSMENT OF NUTRITIONAL STATUS USING ANTHROPOMETRY AND BODY COMPOSITIONS CHARACTERISTICS 108
3.2.1 GENERAL DESCRIPTIVE STATISTICS OF AGE AND ANTHROPOMETRIC VARIABLES 108
3.2.2 GENERAL DESCRIPTIVE STATISTICS OF DERIVED INDICES OF NUTRITIONAL STATUS AND BODY COMPOSITION 109

3.2.3 AGE SPECIFIC DESCRIPTIVE STATISTICS OF AGE AND ANTHROPOMETRIC VARIABLES 112

3.2.4 AGE SPECIFIC DESCRIPTIVE STATISTICS OF DERIVED ANTHROPOMETRIC AND BODY COMPOSITION INDICES 113

3.2.5 CORRELATIONS OF ANTHROPOMETRIC VARIABLE AMONG THE MALE LIMBOO INDIVIDUALS 117

3.2.6 CORRELATIONS OF ANTHROPOMETRIC VARIABLE AMONG THE FEMALE LIMBOO INDIVIDUALS 124

3.2.7 LINEAR REGRESSION OF SEX ON ANTHROPOMETRIC AND BODY COMPOSITION VARIABLES AMONG THE LIMBOO INDIVIDUALS 134

3.2.8 LINEAR REGRESSION OF AGE ON ANTHROPOMETRIC AND BODY COMPOSITION VARIABLES AMONG THE LIMBOO INDIVIDUALS 134

3.2.9 LINEAR REGRESSION OF BMI ON ANTHROPOMETRIC AND BODY COMPOSITION VARIABLES AMONG THE LIMBOO INDIVIDUALS 137

3.2.10 LINEAR REGRESSION OF HEIGHT ON THE VARIOUS ANTHROPOMETRIC VARIABLES OF LIMBOO INDIVIDUALS 140

3.2.11 STEP-WISE MULTIPLE LINEAR REGRESSION OF HEIGHT ON VARIOUS ANTHROPOMETRIC VARIABLES AMONG LIMBOO INDIVIDUALS 143

3.2.12 ASSESSMENT OF NUTRITIONAL STATUS USING BMI AMONG THE LIMBOO INDIVIDUALS 145

3.2.12.1 Nutritional status of Limboo adults based on BMI classification of WHO (1995) 146

3.2.12.2 Nutritional status of Limboo individuals based on BMI criteria of WHO (2000). 150

3.2.13 ASSESSMENT OF UNDERNUTRITION USING MUAC AMONG LIMBOO INDIVIDUALS 154

3.2.14 ASSESSMENT OF CENTRAL ADIPOSITY AND OVERALL ADIPOSITY AMONG LIMBOO INDIVIDUALS 158

3.2.14.1 Age specific prevalence of central adiposity among Limboo individuals 160

3.2.15 EVALUTION OF ADIPOSITY USING BMI IN COMBINATION WITH WC, WHtR, WHR, AND CI 166

3.3 BODY FAT AND FITNESS AMONG LIMBOO INDIVIDUALS. 169

3.3.1 PBF USING COMMONLY QUOTED 25/30 CRITERIA AMONG LIMBOO INDIVIDUALS. 169

3.3.2 EVALUATION OF BODY FITNESS USING NIEMAN (1995) CLASSIFICATION. 170

3.3.3 EVALUATION OF BODY FITNESS USING MUTH (2009) CRITERIA. 174

3.3.4 EVALUATION OF COMPONENTS OF BODY COMPOSITION. 177

3.4 DETERMINANTS OF UNDERWEIGHT, OVERWEIGHT AND OBESITY AMONG LIMBOO INDIVIDUALS.....180

3.4.1 ASSOCIATION OF DEMOGRAPHIC, SOCIO-ECONOMIC, AND LIFE STYLE VARIABLES WITH OVERWEIGHT AND HIGH REGIONAL ADIPOSITY AMONG LIMBOO INDIVIDUALS.....180

3.4.1.1 Association of demographic, socio-economic, and life style variables with high BMI (≥ 25 kg/m^2) among male and female Limboo individuals. 181

3.4.1.2 Association of demographic, socio-economic, and life style variables with high BMI (≥ 23 kg/m^2) among male and female Limboo individuals. 182

3.4.1.3 Association of demographic, socio-economic, and life style variables with high WC (female: > 80 cm; male: > 90 cm) related risk among male and female Limboo individuals. 183

3.4.1.4 Association of demographic, socio-economic, and life style variables with high WHtR (> 0.05) related risk among male and female Limboo individuals.....184

3.4.1.5 Association of demographic, socio-economic, and life style variables with high WHR (males: > 0.9; females: > 0.8) related risk among male and female Limboo individuals. 185

3.4.2 RESULT OF LOGISTIC REGRESSION TO ACERTAIN POSSIBLE DETERMINANTS OF UNDERWEIGT, OVERWEIGHT, OBESITY AND CENTRAL ADIPOSITY.....195

3.4.2.1 Multinomial logistic regression for being underweight, overweight and obese using BMI WHO (1995) classification. 196

3.4.2.3 Multinomial logistic regression for being at high WC (male: > 90 cm; female: > 80 cm).....198

3.4.2.5 Multinomial logistic regression for being at risk of high WHtR(> 0.5). 200

3.4.2.6 Multinomial logistic regression for being at high WHR (male: > 0.90; female: > 0.80).....201

3.5 THE ROC-AUC ANALYSES OF DIFFERENT ADIPOSITY INDICES AMONG LIMBOO INDIVIDUALS WITH REFERENCE TO PBF AND BMI (WHO 2000). 207

3.5.1 ROC-AUC ANALYSIS USING PBF (25/30) AS REFERENCE.....207

3.5.2 THE ROC-AUC ANALYSES OF DIFFERENT ADIPOSITY INDICES AMONG LIMBOO INDIVIDUALS OF SIKKIM WITH REFERENCE TO BMI (WHO 2000) CRITERIA.....212

3.5.2.1 ROC-AUC Analysis using BMI 23 kgm^2 (WHO, 2000) as reference. 212

3.5.2.2 ROC-AUC Analysis using BMI 30 kgm^2 (WHO, 2000) as reference. 216

Chapter 4

DISCUSSION

4.1 APPRAISAL OF DEMOGRAPHIC, SOCIO-ECONOMIC, AND LIFE STYLE RELATED PARAMETERS INFLUENCING NUTRITIONAL STATUS 221

4.2 ANTHROPOMETRIC ASSESSMENT AND NUTRITIONAL STATUS AMONG THE LIMBOO INDIVIDUALS 229

4.2.1 EFFECT OF SEX ON ANTHROPOMETRIC AND BODY COMPOSITION VARIABLES 229

4.2.2 COMPARISON OF MEAN ANTHROPOMETRIC AND BODY COMPOSITION VARIABLES OF LIMBOOS OF SIKKIM WITH AVAILABLE STUDIES 233

4.2.3 EFFECT OF AGE ON ANTHROPOMETRIC AND BODY COMPOSITION VARIABLES 258

4.2.4 REGRESSION OF BMI AND HEIGHT ON OTHER ANTHROPOMETRIC AND BODY COMPOSITION VARIABLES 261

4.2.5 PREVALENCE OF UNDERWEIGHT USING BMI AMONG LIMBOO INDIVIDUALS OF THE PRESENT STUDY 263

4.2.6 PREVALENCE OF UNDERNUTRITION USING MUAC AMONG LIMBOO INDIVIDUALS OF PRESENT STUDY 267

4.2.7 UNDERNUTRITION ASSESSED BY THE COMBINATION OF BMI AND MUAC 268

4.2.8 PREVALENCE OF OVERWEIGHT AND OBESITY AMONG THE LIMBOO INDIVIDUALS OF THE PRESENT STUDY 270

4.2.9 PREVALENCE OF CENTRAL OBESITY AMONG LIMBOO INDIVIDUALS OF THE PRESENT STUDY 279

4.2.10 FAT AND FITNESS AMONG THE LIMBOO INDIVIDUALS OF THE PRESENT STUDY 284

4.2.11 COMPONENTS OF BODY COMPOSITION AMONG LIMBOO INDIVIDUALS OF THE PRESENT STUDY 287

4.3 ASSOCIATION OF SOCIO-ECONOMIC, DEMOGRAPHIC, AND LIFE STYLE VARIABLES WITH NUTRITIONAL STATUS 288

4.4 COMPARISON AND CUT-OFFS ESTIMATION OF NEW INDICES OF ADIPOSITY 295

4.4.1 COMPARISON OF AVAILABLE INDICES OF ADIPOSITY 295

4.4.2 SUITABLE CUT-OFFS FOR BAI AND NC 297

Chapter 5

SUMMARY AND CONCLUSION

5.1 SUMMARY FINDINGS 301
5.2 LIMITATIONS 306
5.3 RECOMMENDATIONS 307
5.4 CONCLUSION 308
REFERENCES

Annexure I